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PROCEEDINGS OF THE SOCIETY OF ARTS

FORTY-FOURTH YEAR, 1905-1906

BOSTON, October 12, 1905.

THE 612th regular meeting of the SOCIETY OF ARTS was held at the Institute in Room 22, Walker Building, on Thursday evening, October 12, 1905, at eight o'clock. President Henry S. Pritchett presided. Seventy-eight persons were present. The report of the previous meeting was read and approved. After brief remarks by the President, in which he spoke of the early history of the Society, Professor Charles-Edward A. Winslow, Biologist-in-Charge of the Sanitary Research Station and Sewage Experiment Laboratory, spoke of the "Disposal of City Sewage."[1] Mr. Winslow outlined the history of sewage disposal, not only in America, but also in England and Germany, and described the principal methods which have been developed and the conditions under which each of these is most suitable for use. He pointed out that the geological and climatic conditions in different parts of the world made it impossible to employ a single method which

[1] TECHNOLOGY QUARTERLY, 18, pp. 317-332.

would give good results in all cases. He described the various methods now in use for the disposal and purification of sewage, mentioning Discharge into Large Bodies of Water, Broad Irrigation, Slow Sand Filtration, Contact Filters, Septic Tanks, and Trickling Filters, and mentioned the work now being done at the Experiment Station of the Institute. The lecture was illustrated by lantern slides showing the construction and operation of plants in which these different methods are employed. The President expressed the thanks of the Society to the speaker, and the Society adjourned.

BOSTON, October 26, 1905.

The 613th regular meeting of the SOCIETY OF ARTS was held at the Institute, Room 22, Walker Building, on Thursday evening, October 26, at eight o'clock. Professor William T. Sedgwick presided, and about 240 persons were present.

Mr. William Lyman Underwood addressed the Society on "The Brown-Tail and Gypsy Moths, Their Life Histories and Some Suggestions for Their Suppression." Mr. Underwood described the way in which these insect pests were introduced into this country from the continent of Europe, and in a very clear and interesting way traced out the life histories of each of these organisms from the egg through the larval and pupal stages to the mature moth, and back to the egg. He showed by a magnificent series of colored slides the natural appearance of each of these organisms in all their stages, and pointed out the characteristics by which each could be recognized. He further described the ravages wrought by these insects, and showed the effect of spraying as a means of preserving vegetation from their action. Mr. Underwood expressed the opinion that the moths could never be completely eradicated, but felt that much could be done to suppress them if each property owner would eliminate them from his own place. He spoke of the efficacy of arsenate of lead as a spray and of "tanglefoot" as a means of entrapping the insects on the trunks of trees and around electric lights. After some discussion, participated in by P. P. Field, Dr. Robert P. Bigelow, Dr. H. P. Talbot, and others, the meeting adjourned.

BOSTON, November 9, 1905.

The 614th regular meeting of the SOCIETY OF ARTS was held at the Walker Building, at the Institute, on Thursday evening, November 9, at eight o'clock. Colonel E. H. Hewins presided. One hundred and twenty-eight persons were present. The minutes of the previous meeting were read and approved. The following gentlemen were elected to Associate Membership in the Society: Mr. Earle B. Phelps, Sewage Experiment Station, Boston; Mr. Herbert O. Keay, Boston and Maine Railroad, Boston; Mr. Albert E. Kimberley, Testing Station, Columbus, Ohio. The presiding officer then introduced Mr. Henry R. Gilson, who addressed the Society on "Submarine Signaling."[1] He described the different systems of signaling through air, both by visual and sound signals, and then gave a detailed account of the new method by which the ringing of a bell is transmitted through water to a specially constructed receiver, or "ear." The applicability of this method to submarine or torpedo boats, warships, and cruisers, as well as to other kinds of vessels, was described, as were also the mechanisms involved. The advantage of this system over visual and sound signals in the air was demonstrated. The lecture was illustrated by means of lantern slides.

At the close of the lecture discussion on the subject was participated in by Professor Stone, of Kansas University, and Mr. Horace B. Gale, of Boston.

A vote of thanks was extended to the speaker, and the Society adjourned.

BOSTON, November 23, 1905.

The 615th regular meeting of the SOCIETY OF ARTS was held at the Institute, Room 22, Walker Building, on Thursday evening, November 23, 1905, at eight o'clock. Professor William T. Sedgwick presided. Two hundred and thirty-eight persons were present.

The following gentlemen were elected to Associate Membership in the Society: Mr. S. A. Breed, Boston; Mr. Kenneth Lockett, Chicago, Illinois; Mr. Julius B. Waterbury, Boston; Mr. Horace B. Gale, Boston; Mr. Henry D. Jackson, Boston; Mr. Henry R. Gilson, Boston.

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[1] TECHNOLOGY QUARTERLY, **18**, pp. 365–381.

The chairman then introduced Professor Percival Lowell, Director of the Astronomical Observatory at Flagstaff, Arizona, who addressed the Society on the subject of "Recent Researches on the Canals of Mars." The lecture was illustrated by a large number of interesting maps and diagrams showing the most important of the so-called canals. The relation of these to vegetation was suggested and theories advanced why vegetation should make its first appearance at the poles and gradually work its way towards the equator. Some interesting slides showing views of the observatory and of the telescopes were also shown.

After a short discussion the Society adjourned.

BOSTON, December 14, 1905.

The 616th regular meeting of the SOCIETY OF ARTS was held at the Institute, Room 22, Walker Building, on Thursday evening, December 14, 1905, at eight o'clock. Mr. George W. Blodgett, chairman of the Executive Committee, presided. One hundred and forty-eight persons were present. The records of the previous meeting were read and approved. Messrs. E. P. Turner and H. C. Turner were elected to Associate Membership in the Society.

The chairman then introduced Professor Robert H. Richards, who addressed the Society on "The Treatment of the Black Sands of the Pacific Coast by the United States Geological Survey."

The speaker described some of the methods used to obtain the sands subjected to treatment, especially hydraulicking and dredging. He also showed the methods of classifying and the results obtained in the experiments conducted at Portland, Oregon, during the exposition, pointing out that the most valuable products obtained were those not sought at the outset of the investigation. The paper was illustrated by lantern slides.

The chairman extended the thanks of the Society to the speaker, and the meeting adjourned.

BOSTON, January 11, 1906.

The 617th regular meeting of the SOCIETY OF ARTS was held at the Institute, Room 22, Walker Building, on Thursday evening, Janu-

ary 11, at eight o'clock. Professor W. H. Niles presided. Thirty-eight persons were present. The minutes of the previous meeting were read and approved.

The chairman then presented Professor Alexander F. Chamberlain, of Clark University, who addressed the Society on the subject of "The American Indian Folklore."

The speaker was tendered the thanks of the Society, and the meeting adjourned.

BOSTON, January 25, 1906.

The 618th regular meeting of the SOCIETY OF ARTS was held at the Institute, Room 22, Walker Building, on Thursday evening, January 25, 1906, at eight o'clock. Seventy-three persons were present. Professor Robert H. Richards presided. The minutes of the previous meeting were read and approved. Mr. W. W. DeBerard was elected an Associate Member of the Society.

Mr. Howard W. DuBois, Mining Engineer, of Philadelphia, Pennsylvania, was then presented by the chairman, and addressed the Society on "Hydraulic Mining in British Columbia and Alaska." Mr. DuBois explained the methods employed in hydraulic mining and the conditions under which they are applicable, and showed by illustrations the great economy of this method as it is used in British Columbia and Alaska.

He also showed a very large number of beautifully colored slides, giving a very clear picture of the scenery in Alaska and of the difficulties in approaching the gold fields.

The chairman extended the thanks of the Society to the speaker, and the meeting adjourned.

BOSTON, February 8, 1906.

The 619th regular meeting of the SOCIETY OF ARTS was held in Room 22, Walker Building, Massachusetts Institute of Technology, on Thursday evening, February 8, 1906, at eight o'clock. Attendance, forty. President Henry S. Pritchett presided. The minutes of the previous meeting were read and approved.

There being no routine business, the President presented the speaker of the evening, Professor Douglas W. Johnson, who addressed the Society on the subject, "Causes and Effects of River Capture."

Dr. Johnson explained what is meant by the term "capture," describing it as a sort of invasion of the watershed of a stream by the tributaries of another system in which the erosive action is going on more rapidly, and whose sources are therefore gradually becoming more remote. The different ways in which this action may take place were shown in a very clear manner, and specific cases in which the capture has been effected were well shown by means of maps and diagrams. The effects of such captures were described in detail, as well as the methods of proving that such changes have taken place.

The lecture was illustrated by excellent stereopticon slides demonstrating salient points.

The President expressed the thanks of the Society to the speaker and declared the meeting adjourned.

S. C. PRESCOTT, *Secretary.*

MODERN LANGUAGE TEACHING, WITH SPECIAL REFERENCE TO PRONUNCIATION AND CONVERSATION

By JOHN BIGELOW, Jr.

The principal uses of foreign languages at college and in a graduate's after life may be stated in order of importance as follows: —

1. Reading.
2. Writing.
3. Speaking.
4. Culture.

It is a common fault of our schools and colleges to place the last of these first, to neglect language for literature, to run to literature, thus entailing long lessons in reading and precluding the proper discussion of their diction and syntax. While the French language is being studied there is no time for discussing the motives and character of the *Cid* or of Tartuffe, or for the explanation of the obsolete words and phrases of Molière, Corneille, and Racine. One should not in this period go back of Balzac for examples of French prose.

The common practice of reading from a French or German reader in English is good mental discipline, and good exercise in the use of English, but is not good training in the use or comprehension of French or German. It defeats what should be the main object of the reading — making the pupil think in a foreign language. If a teacher could look into a pupil's head and see as he reads just what he understands, a recitation in French reading would consist mainly in reading on the part of the pupil, and in observing the working of the pupil's mind, or mind-reading, on the part of the teacher. As it is, the teacher's only way of finding out what the pupil knows is to submit him to a test. But there are ways of doing this without making him speak English. Let the teacher commence by asking the whole class, say in French, what difficulties, if any, they found in the lesson and were not able to overcome. All answers to this question should have to be given in or rendered into French; for instance, "Monsieur, je ne comprends pas

ce que veut dire à la page trente-six, ligne quatorze, le mot 'enseignement'"; or, "S'il vous plaît, expliquez-moi au paragraphe douze, ligne trois, la phrase 'c'est-à-dire.'" The teacher may then proceed to call up in turn the pupils that are to read, and question them in French upon the lesson, or the more difficult parts of it, requiring them as much as possible to answer in French. It will rarely be advisable to go over the whole lesson in this way. This I would call the *question* method.

As another form of test the pupil may be given a number of lines of the reader to translate in writing into English, and be required then to translate his English back into French without looking at the French text. This I would call the *translation* method. As another such exercise, the teacher may read a few lines of the reader in French and have the pupils write it in English and then translate their English into French. This may be called the *dictation* method.

The first, or question method, is the best for small and rather advanced classes. It is the most difficult for the teacher as well as for the pupils. It has the great advantage that it does not involve any use of English, that is, when strictly carried out. An English word will perhaps have to be used now and then. But before resorting to English the teacher should exhaust his ability to make himself understood in French. He should repeat what he says in various forms, explaining by synonyms, signs, gestures, etc., what he judges to be the principal difficulties. A verb which is not understood may sometimes be made clear by a statement in French of the person, tense, and infinitive. If all this fails, he would do well to write what he wants to communicate on the blackboard in French. What is not understood when spoken is often understood when written. If he decides to use English, he should habitually do so in writing rather than orally. If, finally, he does use English orally, he should immediately repeat himself in French, so that the last impression made shall be of French.

The translation and dictation methods both require the writing of English, but do not involve any talking of it. The dictation method has the peculiar advantage that it does not require the pupil to use his book. It is thus independent of notes which he may have made in it, or of the length of time that a reader is kept in use. In the translation method such notes may assist a pupil in writing his English, but as he has to write his French without a text he can have no such assistance in that, the principal, part of the exercise. Moreover, the translation method may be practiced without books, the instructor fur-

nishing the pupils extracts therefrom on loose sheets kept by himself for that purpose. Each of these methods may be abridged by omitting the translation from English into French, or reduced to simple translation into English.

Of the three methods the easiest is that of translation. If taken successively the translation method (whole or abridged) should come first, the dictation method (whole or abridged) next, and the question method last. But they may all be used from the beginning, in alternation with one another. The oral translation of French or German into English should be totally discarded.

Whatever method is employed, the written or spoken exercises should be followed by reading of the French text in French. The usual practice is to read in French first and in English afterwards. The French is often not read at all. When it is read, two, three, or four lines may be read in English to every one that is read in French. This is all wrong. The translation should precede the reading in French, and this reading should be at least as prominent a feature of the exercise as the translation. I consider it a good practice to give the first half of the hour to translation and the second half to reading, and to have the whole class read aloud every passage that an individual pupil is to read, the class reading it before the pupil is designated. Should this be impracticable for lack of time, the whole class should read at least one passage.

In technical or scientific reading the pupils should understand the technology or science that they are reading about. In this, as in other reading, the pupils should know, not only the words that they see and use, but also the things that the words stand for. There are two scientific French Readers that seem to be widely used in the schools and colleges of the United States, each of which gives a description of a steam engine without a drawing, plate, diagram, or graphic illustration of any sort. The average pupil knows practically nothing about a steam engine when he commences to read one of these descriptions, and little if anything when he gets through. The teacher, if he is able to, may make a drawing for his class, and point out the parts as their names are reached. But the instruction is more apt to be confined to words. The pupil may learn that there is in a steam engine a something or other that Americans call a *sliding valve* and that Frenchmen call a *tiroir*, but in what part of an engine a sliding valve functions, what it looks like, what it does, what the word *tiroir* stands for, these are points on which he has at the best but a faint and inadequate idea.

Notices posted on a bulletin board should, as a rule, be in a foreign language. That a notice may possibly not be understood, say in French, is not in itself sufficient reason for putting it in English. Is it necessary that it be understood at all? Many of the notices posted on school and college bulletin boards are of no great importance, or if they are, should be understood in a foreign language. A notice, for instance, about courses in sight reading does not concern any student who cannot read it in the foreign language. Whenever and for whomsoever notices may be posted in English, they should, if practicable, be accompanied by a translation.

As a rule, the texts on blank forms, printed slips, charts, drawings, etc., used in the classrooms should be in the language studied. As illustrations I present the following forms which I have found useful in my own sections. The spaces occupied by the words in italics are left blank. Words not wanted in the instructions are struck out.

LEÇON *38*

Traduisez en anglais et retraduisez en français sans regarder le texte français:

Tout en se hâtant de faire les commissions, Julien regardait le pays. . . .

LEÇON *12*

Écrivez en français:
anglais:

Yes, we visit all the members of our family. . . .

LEÇON *8*

Indiquez de quelle préposition on doit faire précéder les infinitifs qui dépendent des verbes et des expressions suivants: *forcer, se mettre, vouloir, être à même*.....

.....

.....

LEÇON *13*

Écrivez les temps primitifs, l'impératif (s'il y en a), et la $\begin{matrix}\text{première}\\\text{deuxième}\\\text{troisième}\end{matrix}$ personne du $\begin{matrix}\text{singulier}\\\text{pluriel}\end{matrix}$ de tous les autres temps, des verbes suivants:

A la forme affirmative.	A la forme négative.	A la forme interrogative.	A la forme négat-interrog.
Forcer	*S'évanouir*	*Vendre*	*Valoir*
. . . . .	*Punir*	. . . . .	*Se promener*
. . . . .	. . . . .	. . . . .	. . . . .

Pupils should be required in writing out verbs to give the moods and tenses in the language studied. They should be so given in all text-books.

In the translation of measures foreign terms should be converted into American: metres into yards; kilometres, leagues, and German miles into statute miles; kilograms into pounds; marks, francs, and centimes into dollars and cents; degrees Centigrade into degrees Fahrenheit, and *vice versa*.

In the study of a language the one object of the pupil should be to master it, and of the teacher to help him do so. Mental discipline should be considered only as an incident which may be trusted to take care of itself, provided that thoroughness be insisted upon. Lessons and exercises should not be made difficult with a view merely to training the mind. The disciplining of the mental faculties, considered as a separate function of education, may safely and fairly be left to courses which have not the peculiar difficulties of language teaching to contend with.

The acme of linguistic attainment is to speak and write a foreign language like a native. Such perfection is hardly attainable without a residence of years in the home or mother country of the language. Moreover, it is not, generally speaking, worth the time or labor that it costs. Nobody but a spy, or possibly an actor, has need or occasion to pass himself off for a foreigner. On the other hand, it is not enough

for conversation with a foreigner to be able to speak so as to be understood. One must have a pronunciation that will not shock his ears. The object of instruction in oral or spoken French or German should be to speak that language intelligibly and with a tolerable accent.

Teachers talk too much English and not enough of the language that they are teaching. Many of them are foreigners, speaking English with a foreign accent. Much of the time and energy that might be devoted to training the ear to understand a foreign language is worse than wasted in accustoming it to bad English.

The teacher should seize every opportunity of conversing with his pupils. For a considerable time the conversation will be largely one-sided; that is, the foreign language will be nearly all furnished by the teacher. The progress made will depend upon the time available for such exercise and the size of the class or section. But even when the pupils answer in English, something is being done by accustoming their ears to the foreign language. It is a great mistake to suppose that pronunciation must be acquired exclusively by practice therein; that nothing else contributes to its acquisition. Not many years ago the director of modern languages in the Boston schools, addressing a meeting of classical and high school teachers, made use of the following language: —

Now let us suppose that a class of twenty-five pupils, neglecting all else, spends its whole time in "conversation"; let us say that each recitation period consists of fifty minutes, and that the class recites three times a week; let us suppose, also, for the sake of the argument, that the instructor talks only half of the time. What is the result? If the hours are equitably divided, every pupil speaks for three minutes a week, or two hours yearly, or a quarter of a day during his entire public school career. When we reflect that it takes us, with fully an hour's exercise *per diem*, ten or fifteen years to master our native tongue, we can perhaps estimate the amount of skill that is to be produced by six hours' practice scattered over a term of three years. It will then be unnecessary to discuss the question whether or not the ability to speak French or German is a desirable and proper object for a public school course.

The director leaves out of account entirely the speaking done by the instructor and by pupils not addressed by him. He implies that a pupil gets nothing from the speaking done by anybody but himself. I wonder what he thinks of the practice of going abroad to learn to speak a foreign language? If one learns nothing except by speaking oneself, one might as well stay at home and do it there. The speaking done by the teacher is not only helpful, but an essential part of

the instruction in conversation. The speaking of fellow-pupils is also helpful.

In the next place, the director assumes that not more than one pupil can practice speaking at a time. I have found it a difficult thing in my own sections to prevent (when I want to) more than one pupil speaking at a time. It is probably a common experience with teachers when they question a pupil to get two or three or more answers from as many pupils. Speaking by more than one pupil at a time is, in fact, unavoidable, and may be advantageously encouraged and regulated. A whole class or section may be practiced in repeating passages of French together. Occasional errors will pass unnoticed; certain pupils will perhaps lag or not speak at all. But exercises of this sort will be far from wasted, and practiced in moderation, especially during the early stages of instruction, will be found effective, time-saving, and altogether satisfactory.

"It takes us," he says, "with fully an hour's exercise *per diem* ten or fifteen years to master our native tongue." It is not proposed to make American youth "master" any foreign tongue. As to this imaginary, fictitious, daily period of one hour which we are said to devote from the time we are born until we are fifteen years old to exercises in speaking English, at least half of it comes before our brains are fully grown. A large part of our work consists in unlearning what we have learned from bad example. What relation is there between such a period of exercise and a period of equal length devoted to modern language instruction between the ages, say, of fifteen and eighteen? The two values are essentially different. They cannot be expressed or conceived in terms of each other. They are absolutely incommensurate.

Nor is any consideration given to the periods of preparation. Do not three hours of recitation carry with them three hours, more or less, of study or practice at home? If a pupil will only practice by himself reading aloud in French and studying rules of pronunciation he may do a good deal towards the perfection of his accent. It would seem, indeed, but in a sense as different as can be from that of the director's language, to be "unnecessary to discuss the question whether or not the ability to speak French or German is a desirable and proper object for a public school course."

Conversation, which at many of our colleges is a course by itself, should be an essential part of every course of instruction in language, and should commence at the first lesson.

It is a common and lamentable error on the part of teachers to underestimate the capacity of their pupils for conversation. Instead of being ahead of them and leading them on they are too often barely abreast of them or behind them. Nothing is more tiresome or discouraging to a class.

It may be regarded as an axiom in the minds of our teachers and professors that the study of foreign languages should be taken up at an early age; President Eliot says not later than the tenth or eleventh year. But unless pronunciation be taught, what greater mistake could there be than such a practice? As foreign languages are commonly taught in our schools and colleges today, the study of them may be pursued to better advantage between the ages of eighteen and twenty than it can at the age of ten or eleven.

Familiarity with the sound of a language is not only a preparation for speaking it, but a condition to the appreciation of its literature. There seems to be a common disposition to consider spoken language as a sort of extract of written language. It would be far more rational to consider written language as a condensation, a precipitation, of spoken language. The word *language* comes from the Latin word for tongue. It is essentially a form or ultimation of speech. There are two classes of extremists — one utilitarian, the other literary — who want to learn to read without learning to pronounce, to get the sense of a language without its sound. Imagine a man in the lumber business saying to his forester, with a wave of the hand: "I want you to raise trees on this land, but I don't care anything about leaves and branches. Leave all that out; just raise trunks." As the quickening essence of the sun pours through the leaves into the sap and fiber of a tree, so the genius of a people flows from their mouths as a stream of life into the grammar and vocabulary of a language. Reading, the utterance or silent apprehension of writing, is but an echoing of speech. People who profess to teach French or German without teaching to speak it may be teachers of French or German grammar or vocabulary, but not of the French or German language.

Pupils take more interest in a language as living than they take in it as dead. Parents wish their children taught the pronunciation of the languages that they study. Members of faculties, corporations, and similar bodies, seem generally to disbelieve in language without speech. It is almost solely among teachers and professors of languages that one finds apologists for the obnoxious pedagogy by which so many of them are producing deaf and dumb virtuosos in foreign literature. The neg-

lect of conversation in the instruction and study of foreign languages accounts in a measure for the tendency of instructors to rate students in this subject by hours or years of work done rather than by proficiency attained, and for the disposition of students to look upon the subject, not as an accomplishment or a talent that shall contribute to their happiness and usefulness in after life, but as a "grind," to be worked off as a condition to advancement in some school or college curriculum. Men come to me from our foremost universities and ask, almost demand, that they be excused from the study of French because of the number of years that they have pursued it, exhibiting ofttimes a list of the French books that they have read. I remark, "Alors vous parlez français, n'est-ce pas?" The usual reply is a look of surprise mingled with indignation or amusement, according as the question is taken seriously or as a joke.

Much of what is said by a teacher to his pupils, habitually in English, may just as well be said in a foreign language. It takes practically no longer to say, "Allez au tableau noir," than it does to say, "Go to the blackboard"; to say, "Asseyez-vous," than to say, "Sit down," or "Take your seat"; to say, "Ouvrez vos livres à la page vingt-cinq," than to say, "Open your books at page twenty-five"; to say, "Y a-t-il quelque chose dans la leçon que vous ne comprenez pas?" than to say, "Is there anything in the lesson that you do not understand?" These phrases would have to be explained perhaps once or twice, but being used over and over again, they would soon become familiar to the pupils. These and other locutions too numerous to mention or illustrate, used by every teacher as commonly as these, would become fixed in the average pupil's memory, and serve as nuclei for other sentences, as the beginning of a practical vocabulary and standard of pronunciation.

The strictly useful vocabulary of the pupils should be developed, not only by asking questions and requiring them to answer in French, by making conversation with them, but also and particularly by requiring them to put into French questions which they voluntarily address to the teacher in English — questions, for instance, as to the meaning of passages in the lesson, as to marks given them, as to books or other articles lost or found, etc. The lessons should habitually be given out in French, whether orally or in writing.

When a pupil is called upon to spell a French word aloud he should be required to spell it in French. A large proportion of our students of advanced French do not know the French alphabet. All parsing or

analyzing of sentences should also be done in French. In dictating in French the punctuation marks should be given in French. These and the parts of speech should be taught with the alphabet or the elements of pronunciation. While a teacher is correcting an exercise in French at the blackboard, he should read it aloud in that language. The teachers in their intercourse with one another, especially in the presence and hearing of pupils, should talk one of the languages taught. These are but instances of ways in which pupils may be indirectly and unconsciously impressed with the forms and sounds of a foreign language.

Pronunciation being recognized by the governing body of a school or college as an essential part of a language, the next thing is to bring the fact home to the pupils. The instructors should keep separate marks for pronunciation. The general or record mark should be the mean between the marks for *pronunciation* and for *grammar*, etc. For grading in pronunciation I venture to suggest the following scale based on the one in general use at the Institute of Technology.[1] The term "audible" means that can be heard and recognized as the language used at a distance of about 20 feet, and the term "tolerable," that can be listened to without pain by one who knows the language.

C	Audible, intelligible, tolerable, fluent, expressive	. . . .
P+	Audible, intelligible, tolerable, fluent	Inexpressive
P	Audible, intelligible, tolerable	Halting
L	Audible, intelligible	Intolerable
F	Audible	Unintelligible
FF	. . . .	Inaudible

Practice in the pronunciation of French is commonly begun on words and phrases. Better results may be obtained by beginning on the elementary sounds. A pupil in music is made to learn the notes before he begins to play bars. There has been, indeed, in recent years a school of reading that makes a child learn words before he is taught his alphabet. This method is responsible for much of the bad spelling of our school children and college students, and is now, I understand, generally discarded.

[1] C, passed with credit; P, passed; L, passed with low standing; F, failed to pass; FF, failed completely.

The following exercises are offered as an aid to teachers in conducting systematic drill in the pronunciation of French.

Vertical lines are placed as warning signals where changes of sound are to be made. The more important changes are signaled by double lines //.

First Exercise

The first exercise is divided into two paragraphs. The first consists of the alphabet. In the second paragraph the vowels are given, first by themselves, and then preceded by those consonants and combinations of consonants which offer some difficulty to English-speaking students.

The French *w*, which has two sounds (Eleventh Exercise), is here given its more common sound, or that of *v*. This exercise should be practiced along the horizontal lines and along the vertical lines or columns. Especial attention should be given to the *u* sound. In connection with the line *ra, re,* etc., it may be well to give a little practice in the Sixth Exercise, to be resumed and perfected when that exercise is regularly reached.

1. a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z.

2.

a	e	i	o	u	y	ou	oi	é	è	ê
ha	he	hi	ho	hu						
va	ve	vi	vo	vu						
wa	we	wi	wo	wu						
ga	ge	gi	go	gu						
ja	je	ji	jo	ju						
cha	che	chi	cho	chu						
qua	que	qui	quo	qu						
ra	re	ri	ro	ru						
ca	ce	ci	co	cu						
ça			ço	çu						

Second Exercise

The vowels are used in this exercise as parts of words. In some of these they sound as when alone; in others their sound is affected by other vowels, by adjacent consonants, by accents, or by diereses.

There are sounds that are easy to pronounce separately, but present considerable difficulty when occurring together. One may be able to pronounce the *u* and the *ou* sounds each by itself, but not the two united, as in the word *voulu*. For this reason special attention should be given to the portion of paragraph 6 following the word *août*.

1. la, ta, sa, mal/ Saar, Saale/ âne, âme// laid, mais, jamais// maïs, Sinaï// au, corbeau, chevaux/ Maure, Minotaure, restaure.

2. ne, me, se, te, le/ jeu, œufs, nœud, vœu/ œuf, seul, leur, veuve.

3. les, mes, et, parler, mener, blé/ cher, sel, sexe, peine, Seine, neige, terre, cette, nette, très, père, même// poêle, poêlier.

4. ni, si, fini/ Nîmes, fîmes, vive, assise.

5. dos, gros, mot, trône/ bonne, folle, molle, comme, personne// moi, soi, vois, foie/ noyé, noyau/ boîte, boiter, boiteux, coiffe, coiffer, coiffeur// Moïse, égoïste.

6. du, mur, fume, futur, suture/ luire, liure/ nuage, au fur et à mesure// suer, tuer/ sueur, tueur// louer, nouer/ loueur, noueur// mou, fou, août// sus/ sous// au dessus/ au dessous// sur/ sourd// pur, pour// surtout/ pourvu// du tout/ voulu.

Third Exercise

The nasal sounds are given in paragraph 1 of this exercise by themselves, and in paragraph 2 in combination with other letters, forming words. They should be pronounced without any twang.

There are nasal sounds which like the sounds *u* and *ou* (Second Exercise) are particularly hard to render distinctly one immediately after the other. This exercise affords practice in doing this.

The non-nasal sound of *am*, *em*, *om*, *on*, and *en* is illustrated in paragraph 3.

1. an, en in on un oin

am, em ain om eun

ean ein

2. ban, flanc, dans, Jean, mangeant, vent, sens, serment, champ, jambe, temps, membre/ fin, malin, pain, bain, sein, frein/ bon, don, plomb, allons/ aucun, quelqu'un, jeun// foin, coin, point// menti, monta/ enfant// maintien, lointain// mentant/ montons/ menton, montant// trempons/ trompant// enfin, singeant/ en plein, pinçant/ enfantin, intendant, embonpoint.

3. flamme, femme, ardemment, patiemment/ comme, personne/ solennel.

Fourth Exercise

One may pronounce the several syllables of a word perfectly, and yet betray one's unfamiliarity with the word and with the language to which it belongs by misplacing the tonic accent. An Englishman or American says "character," placing the accent on the first syllable; a Frenchman says "caractère," placing it on the last syllable; a German says "Karakter," placing it on the second or middle syllable. Thus in pronouncing practically one and the same word one is speaking English, French, or German, according to where one places the tonic accent. In French the tonic accent is invariably placed on the last syllable, words joined by a hyphen being intoned in this respect as a single word.

The tonic accent is ordinarily soft, gentle, often hardly perceptible, but it is always there. Let it be misplaced by only one syllable, and an ear used to the harmony of the French language will not fail to hear its false ring. Beginners in this exercise may unduly emphasize the last syllable or exaggerate the tonic accent, but this fault will correct itself.

In our country little attention is given by teachers of French to the tonic accent, even in those schools and colleges that pretend to teach pronunciation. A teacher who has a perfect pronunciation himself — he may be a Frenchman — will sit silent and unmoved while a pupil perpetrates such atrocities as *nátion, refúser, retoúrner, curiósité, révolútion, civilizátion.* The explanation of this seems to be that the teachers

do not know the law of tonic accentuation themselves. They have probably acquired their pronunciation without rule or law; in other words, by the natural method. They may perceive that the pronunciation of their pupils is wrong, but not know what is the matter with it or how to correct it. The head of the department of modern languages at one of our great institutions of learning directs that in the pronunciation of French there shall be no tonic accent; all syllables of the same word to be intoned alike. This is an anatomical impossibility. One cannot, except by a *tour de force*, pronounce words of more than two syllables without using a tonic accent. One who is not taught to place that accent right will almost inevitably place it wrong.

This exercise consists of three paragraphs. The first gives words of two syllables, followed by words of three or more formed by additions to the original words. The pronunciation of these words calls for a continual transference of the tonic accent to the last syllable.

The second paragraph consists of words which are spelled the same, or nearly the same, in English as in French. Great care or proficiency is required to avoid putting the emphasis where it belongs in English instead of where it belongs in French.

The last paragraph is formed of a few words and phrases containing hyphens.

1. dessin, dessiner; engage, engager, désengager; personne, personnel, impersonnel, impersonnellement; avant, avantage, désavantage, désavantageux, désavantageusement.

2. science, cordon, cordage, bureau, union, caractère, caractéristique, chocolat, carcasse, cardinal, bataillon, discipline, institut, université, technologie, culture, sépulture, Jules César, Napoléon Bonaparte.

3. peut-être, moi-même, viens-tu, va-t-en.

Fifth Exercise

This is an exercise in the liquid *l*.

1. ail eil euil ille ouille uille
aille eille euille
œil

2. bail, détail, faille, tressaille/ conseil, veille, vieille, abeille/ deuil, accueil, veuille, feuille/ fille/ fouille, mouille/ aiguille, juillet.

Sixth Exercise

The first paragraph of this exercise is devoted especially to the letter *r*. It is made up of words containing that letter and having the same form, or spelled alike, in French and in English. To bring out the difference between the English *r* and the French *r*, each of these words should be pronounced first in English and then in French.

The second and third paragraphs are devoted to the terminations *re* and *le*, respectively. English-speaking people are prone to pronounce these like the English terminations *er* and *le;* to sound the last syllable in the French words *sabre* and *sable* like the last syllable in the English words *saber* and *sable;* to render, for instance, *tout ensemble*, toot-on-sóme-bull. In the French word the *e* is heard, if at all, after the *r* or *l;* the sound of the *r* or *l* immediately follows that of the preceding consonant.

1. rat, rare, respect, ridicule, robe, rude, rupture, lucre, bronze, profit, quadrille, Rome, Paris, arc, retort.

2. battre, acre, fiacre, arbre, marbre/ cadre, sabre, âpre, âcre// neutre, feutre// lettre, guêtre, nègre, algèbre, maître// vitre, cidre// mordre, propre// foudre, coudre, poudre, pourpre// sucre, lustre, lugubre, huître// encre, gendre/ timbre, peindre, moindre/ contre, montre, monstre, Montmartre/ croître.

3. fable, sable, table, débâcle/ peuple, meuble/ règle, siècle, aigle, faible// cible, nuisible/ noble/ double// multiple, quintiple, muscle// semble, tremble// simple, épingle// comble, ongle, oncle/ humble, jungle// misérable, formidable, inévitable.

Seventh Exercise

The French have two sounds of *gn:* one liquid, as in the English word *singing;* one hard, as in the English word *ignorant*. Both are illustrated in this exercise.

Espagne, espagnol, baigna, saigna, seigneur, signifier, magnifique, magnolier, Boulogne, ivrogne, ignoble, ignorer, imprégner, ignorant// igné, stagnant, inexpugnable.

Eighth Exercise

This exercise is devoted to the pronunciation of the French *ti* followed by *a*, *o*, or *e*. It never has the *sh* sound of the English *ti* in such words as "attention." This should be impressed upon the pupils at the start.

partial, initial, insatiable, Dalmatie, facétie, démocratie, aristocratie, captieux, factieux, facétieux, ambitieux, initier, balbutier, partiel, essentiel, fiction, friction, faction, fraction, nation, national, association, Egyptiens// tiare, centiare, partie, sortie, septième, maintien, soutien.

Ninth Exercise

Words containing *h* mute.

l'habitude, l'hiver, l'hôtel, j'hésite/ bonheur, aujourd'hui, exhaler, inhabile, exhausser, exhaussement/ renhardir, enharnacher, déharnacher, cohorte, dehors, envahir/ la haine, les haines, je hais, la halte, le héros/ le chapeau d'Henri/ la mort de Henri IV.

Tenth Exercise

This exercise is devoted to the letter *w* at the beginning of certain words. In the words preceding the sign / it is sounded like *v*. In the words following that sign it is sounded as in English. The *i* is sounded as in French (First Exercise). The *ey* in *whiskey* is pronounced like *i*. The *h* is not sounded.

Wurtemberg, wagon, Watteau, Wagram/ whig, whist, whiskey, Wiclef, Windsor.

Before requiring the pupils to read these exercises the teacher should explain their general purpose, and go through them, reading and expounding each one. The exercises should be printed or drawn in the form of charts and kept in the classroom, so that when a pupil makes a serious mistake in pronunciation he may be referred to the appropriate exercise and practiced in it. The exercises should also be distributed to the class in convenient form for study at home, each French word accompanied by the corresponding English one. At the beginning of a course the exercises should be taken in succession, one or two at a time, for systematic drill.

I know that the teachers in our high schools have to prepare pupils for colleges, universities, and technical schools which do not require pronunciation for admission, and do require a certain knowledge of grammar and a considerable amount of reading. But I believe that, without trenching materially on the time given to these subjects, much may be done to improve the training in pronunciation. It should be impossible for a boy to escape from a year's course in French at any school with such a Franco-American travesty of a pronunciation as the average student brings to the Institute of Technology every year. It should not devolve upon instructors at the Institute to take graduates in school French through the French alphabet.

The art of teaching pronunciation has recently received from the mechanic arts a most valuable contribution, which has hardly begun to be appreciated. I refer to the *graphophone*, *languagephone*, or *talking machine*. No matter how small the class, a teacher cannot give it all the training in pronunciation that it is capable of receiving. Even assuming a single pupil to a teacher, one cannot suppose the pupil to have the teacher with him ready to pronounce for him whenever he may want to practice. A talking machine is always ready. This substitute for a teacher he can have practically whenever and wherever he wants it, and as long as he wants it. If he should try to get the equivalent of a machine in two or three teachers, he would experience the disadvantage of a change of models. No two persons pronounce exactly alike. Even the same person will vary his pronunciation. The talking machine is always the same, and all machines of the same make are alike. So one may have one invariable model in any single machine or any number of machines. This uniformity is an appreciable advantage in the early lessons. The peculiar merits of the talking machine are *indefatigability* and *invariability*.

I have been able to learn of but three types of the talking machine that are at present in use in teaching languages. These are the *Victor*, the *Columbia*, and the *Edison*. As an implement of language teaching, each of these machines is monopolized by a particular school or company: the Victor by the United States School of Languages, Main Office, 1127–1129 Walnut Street, Philadelphia; the Columbia by the International College of Languages, Main Office, Metropolitan Building, Sixteenth Street and Broadway, New York; the Edison by the International Correspondence Schools, Main Office, Scranton, Pennsylvania. Outfits, consisting of a machine with a supply of disks or cylinders,

books or manuals, and other appurtenances, are offered by these schools for sale at prices varying, as listed, from twenty to fifty dollars.

I expect the talking machine to prove useful in our schools and colleges in general, especially in helping along the few students in a class who may be considerably behind the rest or considerably in advance of it and ambitious or zealous in pronunciation. No matter how well one may be doing with a teacher alone or with a machine alone, one will do better with both, each more or less correcting the faults and supplementing the work of the other.

Not until proficiency in the first three uses of foreign languages — in reading, writing, and speaking — is attained or assured should the fourth use, or culture, be regarded as the chief purpose of instruction. The skipping or slurring of the alphabet, pronunciation, and composition to get at literature tends to accustom or reconcile a pupil to superficial study. The practice is an evil which school committees, college faculties, and other bodies having direction of education cannot be too prompt and vigorous in eradicating. They should repeal the requirement that applicants for admission to college shall have read from a hundred to three or four hundred pages of literature, and substitute for this requirement an examination in pronunciation corresponding to the laboratory examination in chemistry and physics.

Any one who holds the study of literature in esteem will deprecate the error of entering upon it with an inadequate command of language.

Literature should not be taken up as the sole or main subject of a course until the pupils are able to recite, follow lectures, take quizzes, etc., in French, German, or Spanish, as the case may be. A course of literature, forming part of a course in a foreign language, should be given only in that language. This stage of instruction cannot be reached at the Institute of Technology until about the end of the regular course or the middle of the advanced (optional) course. Instruction at this final stage should aim primarily at imparting an interest in and appreciation of foreign literature; and, secondarily, at developing, in conjunction with other studies, a taste and a certain fitness for every form of intellectual activity.

THE SCOPE OF APPLIED GEOLOGY, AND ITS PLACE IN THE TECHNICAL SCHOOL[1]

By DOUGLAS WILSON JOHNSON

An attempt to classify scientific work and workers may be a hazardous undertaking. At the same time it is occasionally necessary, for the sake of clearness, to make such an attempt. In order to present certain considerations relating to applied geology, it seems best to recognize three phases of scientific work, with corresponding groups of scientific investigators, students, and schools. The broad classification thus suggested appears to follow lines that are natural and easily recognized, although individual cases may present special difficulties.

Scientific research may be pursued primarily for the discovery of Nature's truths and a knowledge of the workings of her laws. There may be no attempt to obtain knowledge that will have a market value, and when finally attained the results of such research may be wholly worthless from the commercial point of view. To say that they have no *practical* value is not just, for they may possess a very high educational value, and the extension of our educational resources is a consideration of the greatest practical importance. A study of the successive stages in the development of a group of fossil shells, together with the bearing of that development on the theory of evolution, is an example of that phase of scientific research which is generally carried on without regard to the cash selling price of the knowledge obtained.

On the other hand, research may be conducted in a thoroughly scientific manner for the solution of a definite problem presented by commercial interests, with the primary object of making great financial gains. The investigator would not spend a moment on the work did it not promise to have a certain market value. The stimulus to prolonged and patient labor, as well as the initial cause of the investigation,

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[1] Reprinted from Economic Geology, I, No. 3, December-January, 1906.

must be considered as financial in character. As an example of this class of scientific research we may cite the attempts to solve the problem of economically treating titaniferous magnetite, in the hope of making the great deposits of this ore of iron available and of securing valuable monetary returns.

Intermediate between these two classes of scientific work is that class of study carried on with a certain regard to the commercial value of the results to be obtained, but not for commercial reasons primarily; and with an enthusiastic interest in the work for its own sake, but with the requirement that the branch of work selected must have something more than a merely educative value. It is apparent that such a class of work occupies the middle ground between the purely philosophical researches on the one side, and the purely commercial investigations on the other.

Associated with these three phases of scientific work we find three groups of investigators, both students and teachers, and three classes of schools. It is one function of our large universities to encourage the best in philosophical and educational work, and to this end they maintain schools of pure science. Research along lines that promise no financial reward is provided for by endowment. Here we find most of the teachers who have an enthusiastic interest in original investigations conducted without regard to the monetary value of the results to be obtained, and here come those students who have determined to devote their lives to the study of nature's laws, even at a great financial sacrifice.

The university is not a money-making institution, however, and we should not expect to find it actively engaged in furthering investigations for the main purpose of selling the results for a large cash consideration. Accordingly we must look elsewhere for the teachers and students engaged in scientific investigations which are stimulated by commercial needs and the promises of financial gain. From the nature of the case much of this class of work is done independently by individual workers rather than by organized schools. Large commercial enterprises sometimes justify the maintenance of research laboratories, where special problems of immediate importance to their success are worked out by skillful investigators, and where younger assistants may get valuable training. At other times these enterprises profit by securing the services of outside workers for a limited time or for a special problem; and such workers are often teachers in the universities or

technical schools, who devote the most of their time to one of the other two classes of investigation here considered.

The intermediate phase of scientific work, neither purely philosophical nor purely commercial, occupies a most important place in our educational institutions. It is not alone the function of the university to provide for philosophical and educational advancement, it must also provide training for those men who are to take the lead in commercial enterprises. Such a training to be most efficient must prepare the student to take the results of the more philosophical investigations and apply them to the practical problems of every-day life. So it is that our large universities maintain technical schools, or schools of applied science, as well as schools of pure science. The same field is occupied by our various independent technical schools. In these schools we find a class of teachers who are interested in their several lines of scientific work for something more than financial reward, else they would be occupying better paying positions in commercial concerns. Yet they must be keenly interested in the practical commercial applications of their work, for that is the side of the work which they are called upon to emphasize. To these schools come those students who look forward to a life of professional business activity, and who desire to provide themselves with the best possible equipment with which to meet the keen competition of the commercial world, hoping thereby to be successful in financial enterprises. This whole question of the application of scientific principles to the solution of practical problems is one of engrossing interest, and of paramount importance to the technical school. Certain phases of this question, especially those involving the application of geological principles, are here presented.

The term *applied science* may be so interpreted as to cover a very wide field. As here used, the term refers to the application of the principles of the pure sciences, such as psychology, biology, geology, physics, mathematics, etc., to the more practical problems encountered in engineering and other professions. The psychologist may spend years in investigating mental processes and discovering the reactions that normally take place in response to certain stimuli, without ever making use of the results obtained to determine the sanity or insanity of a person, to follow the workings of the criminal mind, or to locate an area of the brain that is suffering from some pathological condition. This is pure science. But when the psychologist himself, or the expert in the treatment of mental diseases, or the criminologist takes advan-

tage of the results obtained by the researches of the psychologist to solve some such practical problem as those indicated, we have to deal with applied science. The neurologist may spend a lifetime in studying the paths of certain nerves in the body of the fish, he being a teacher and investigator in pure science alone. The physician who profits by the discoveries of the neurologist to treat successfully certain nervous affections which before baffled every effort of the medical profession is studying and practicing applied science. The palæontologist studies, classifies, and describes the various forms of fossil shells, and is properly regarded as an investigator in pure science. But when he or any other employs the knowledge thus acquired to locate beds of ore, rock valuable for economic purposes, or artesian water-bearing horizons, a practical application of pure scientific knowledge has been made, and the work belongs in the realm of applied science.

The teacher of applied science occupies a unique position. He stands between the realm of pure philosophy and pure commercialism, and must have a good measure of familiarity with both. He must be in close touch with every advance in his special branch of pure science and with modern methods of investigation. To do this successfully he must himself be an original investigator, actively engaged in promoting the advance of knowledge in his particular field. Only thus can he hope to come into that vital touch with other workers along the same line that will enable him to fully appreciate all that they are attempting and accomplishing, and to judge intelligently the results of their labors. He cannot, however, shut himself up in the realm of pure science, for he must keep in close contact with those departments of the commercial world which find his branch of science of special value in the solution of practical problems. It is essential that he appreciate the needs of commercial enterprises, for only thus can he know where and how to apply his scientific knowledge for the accomplishment of the most good. He must know the problems of the commercial world, the possible solutions discovered by the scientific world, and be able to apply the latter to the former.

In referring to the broader aspects of this problem, "applied science" has been defined as the application of scientific methods and principles to the study of practical problems. If this definition be essentially correct, then "applied geology" is the application of geological methods and principles to the study of such problems. These problems are encountered for the most part by those engaged in engi-

neering work, more especially the mining engineers, civil and sanitary engineers, topographers, and others whose duties involve a study of the earth's surface or extensive operations carried on below that surface.

In a recent number of *Economic Geology*,[1] Mr. F. L. Ransome, in a most interesting article on "The Present Standing of Applied Geology," makes "applied geology" a synonym for "economic geology," and suggests very narrow limits for the term, in the following words: . . . "as a synonym of *economic geology*, or what the Germans call *praktische Geologie*, the term *applied geology* is so obviously convenient to express the application of general geological methods and principles to the study of valuable mineral deposits as to warrant its use with this special meaning."

It would seem, however, that if applied science means more than the application of scientific principles to the study of valuable mineral deposits, then applied geology should include much more than the application of geological principles to the study of such deposits. So long as geological principles are applied, we have to do with applied geology, whether that application be made to the excavation of a tunnel for a railway, the development of a body of iron ore, or the location of artesian water supplies.

One very important branch of the United States Geological Survey is engaged in applying geological methods and principles to the development of artesian and other supplies of water. Large railroad corporations retain the services of geologists for other purposes than the investigation of the mineral resources along their lines. Engineering companies engaged in the construction of subways for trolley lines, canals, dams, reservoirs, etc., have their consulting geologists. The dredging of ship channels in rivers and harbors and the keeping of those channels open, the construction of levees to prevent the flooding of great rivers, the building of jetties to direct and control the flow of rivers, all demand some knowledge of geological forces and the laws according to which they operate. Our engineering schools recognize these facts, and provide instruction in the application of geological methods and principles to engineering problems other than those which involve the study of mineral deposits. In some cases this instruction is given in connection with courses in general or structural geology; in others special courses in applied geology are offered. At the Massa-

[1] Economic Geology, I, No. 1, pp. 1–10.

chusetts Institute of Technology there has been given to civil engineering students, for some years, a course entitled, "Applied Geology." The bearing of geology upon civil engineering operations is emphasized, with little or no reference to mineral deposits.

It is true, however, that the application of geological principles and methods to the study and development of mineral deposits constitutes one of the most important departments of applied geology. Probably the majority would consider it by far the most important of all, and it is not surprising, therefore, to find text-books entitled, "Applied Geology," which actually deal with only this one branch of the subject. For example, we have Burat's "Géologie Appliquée," the more expanded title of which shows it to be simply a "Traité du Gisement et de l'Exploitation des Minéraux Utiles," with a few preliminary chapters on certain more general geological considerations. On the other hand, we have an American text ("Applied Geology," by S. G. Williams) which regards applied geology as "the applications of geology to the various uses of mankind," and which, therefore, discusses the relations of geology to railroad and other tunnels, foundations of engineering and architectural structures, dams, reservoirs, canals, springs, wells, drainage for agricultural and other purposes, sanitation, agriculture, etc., while the various economic minerals are treated at considerable length. An English text on "Practical Geology" (D. T. Ansted), a term used by most writers as a synonym of "applied geology," outlines the limits of the subject in the following words: "I understand by the expression 'practical application of science,' an account of the different methods by which the various facts of the science, as discovered by actual observation, and the general laws which have been deduced from a careful study of the true value and analogies of those facts, may be shown to bear upon the pursuits of practical men, assisting them in coming to right and useful conclusions in their ordinary business. I hope to be able to show that the facts of geology already recorded, and the general conclusions arrived at, may be thus made use of in the ordinary affairs of life and applied immediately to practical purposes." This author considers that "the application of geology to mining must ever be the first and the most deeply interesting of all branches of practical geology." He then devotes some nine chapters, including nearly two hundred pages, to various phases of mining geology. "But mining in all its branches," we read, "is only one department of practical geology." So there follow some half a dozen chapters,

including nearly a hundred pages, devoted to a discussion of the uses to be made of geology in road and canal making, the construction of harbors, breakwaters, quays and bridges, the location of railways and of building sites, the draining of lands, the driving of wells, and in coming to a proper understanding of the decomposition of building stones, the formation and mixture of soils, the behavior of springs and wells, etc. The German interpretation of "*praktische Geologie*" is not always the same, Keilhack's "Lehrbuch der Praktischen Geologie" dealing rather with the making of maps, the preparation of rocks and minerals for study and the methods of investigating their characters, the study of fossils, etc., than with mining geology.

The exact interpretation of such a general title as "Applied Geology" is not a matter of prime importance, however, and enough has been said to show how different such interpretations may be. It might be said, in partial explanation of the more limited usage of the term, that the time was when mining geology was the only "*praktische Geologie*," and the terms were more truly synonymous than today. As a result of the great growth of the science, many practical applications of geology are made today that were not dreamed of when the term "*praktische Geologie*" first came into use. It is also true that a writer often applies the general term to the more specialized work, without any intention of restricting it to that phase of the work alone.

It is believed, then, that the scope of applied geology most properly includes all applications of geology to practical problems. If this be true, then the subject must occupy an important place in every thoroughly equipped technical or engineering school. The students in mining engineering are not prepared to enter on their work until they have acquired a knowledge of the fundamental principles of general geology, and more especially a knowledge of the minerals and rocks with which they will have to deal, the structural features of the earth's crust and their relations to valuable deposits that may be involved in those structures, the geological relations and possible origin of the more important deposits in the country, together with some conception of the present state of our knowledge concerning the origin and classification of mineral deposits in general. They should, if possible, be given some practice in geological mapping, to the end that they may be able to plot the surface geology of a mining region, and from that gain some idea regarding the underground structure in which the deposits are involved.

It is not the purpose of a course in mining engineering to fit a student to take up, immediately upon graduation, the duties and responsibilities of a full-fledged mining engineer. Practical experience in mining regions is a part of the training that must come after the years spent in a technical school. The object of the engineering education is to give the student a broader and in some respects a more exacting training than he is likely to get in his practical experience in some one locality for years to come; to give him an extensive view over the whole field of his chosen work, such as he would otherwise get only after many years of experience; to open his eyes to the possibility of bringing to the solution of problems he may encounter many factors of which he must otherwise remain largely in ignorance; thus to fit him to meet successfully the emergencies that may arise in his professional duties with an intelligent, accurate, creative mind. Experience has shown that a knowledge of geology has often proven necessary to the proper solution of mining problems. Indeed, every mining proposition is a geological problem, be it simple or complicated. Hence a thorough training in geology is essential if the engineer is to bring to his aid in solving mining questions the factor that often affords the greatest help.

A recent editorial in the *Engineering and Mining Journal* calls attention to the great need of keeping careful and intelligent records of the geological features exposed in the course of underground workings, especially as those workings may later be abandoned and become inaccessible through caving, or for some other reason. As is there pointed out, only the largest mining companies can afford to maintain a special geological department, and many cannot even retain the services of a geologist. Nevertheless the records should be kept as well as is possible, as "the results would be of more or less value according to the competence and fidelity of the observer." A geological training should be such as to enable the engineer to appreciate the great importance of the matter in question, and also enable him to keep such records intelligently and work out from the evidence thus accumulated many points of value to his employers. That this is not asking too much of the young engineer is indicated by the important results already achieved by recent graduates in certain cases.

The civil engineer must be prepared to meet many problems involving geological factors, and must therefore be equipped with an adequate geological training. As a foundation a general course in the

fundamental principles of geology seems essential. Familiarity with the different rock species, and a knowledge of their relative values as building material, road metal, etc., will save the engineer from many costly errors. The effect of rock characters and rock structures on tunneling, the need of lining tunnels which penetrate certain rocks which at first appear massive and strong, the danger of caving where shearing planes dip toward the excavation, the possibility of continued slipping of morainal deposits along a railroad cut in such material, the probable changes that may be expected in a river meandering in its flood plain, the possibility of locating water-bearing beds, building stones, and cement rock even when they do not appear at the surface, the conditions essential for the accumulation of artesian waters, and the methods of forecasting the probable behavior of wells to be drilled — these and many other subjects afford abundant material which may be brought to the attention of the civil engineering student with profit. The topographer needs systematic training in the relations of geology to the varied topographic features of the earth's surface. He is called upon to represent the earth's surface not by an actual copy, but rather by an abstract of its features. No contour map is made by determining the position of every contour with accuracy; on the contrary, a limited number of points are so determined, while the topographer must sketch in the remaining areas. The scale does not admit of copying all features, and the topographer who is to make a map which will show the significant features with expressiveness must have an understanding of the subject with which he is working. It is not good policy to have an important work on astronomy reviewed by a person who knows nothing of the science of astronomy. Having no appreciation of the subject with which he is asked to deal, he can hardly hope to present an accurate and properly proportioned abstract. Neither can the topographer achieve the best results so long as he has no knowledge of the land forms which he is required to reproduce in a map abstract.

The sanitary engineer finds that he must have certain kinds of soil for various processes of sewage disposal and water purification. Where the loose sands of glacial deltas, outwash plains, or other deposits of like composition are available, certain of these processes may prove practicable; but where only beds of compact clay or till are found, the cost would be prohibitive. The draining of swamps that prove a menace to public health may sometimes be accomplished by boring through to underlying beds of loose sand or gravel, from which the waters find

a ready outlet. The direction in dip of the rock structures may determine the liability of cesspools to contaminate sources of drinking water at considerable distances. The direction of flow of underground waters may cause or prevent such contamination. Such are a few of the considerations that appeal to the interest of the sanitary engineer.

The many applications of geology to these and other branches of engineering cannot be enumerated here, the points above mentioned merely serving to indicate in a general way the extensive scope of the subject. The methods of presenting these practical considerations to the students must vary with every school and every instructor. It will probably be agreed by most of those engaged in teaching applied geology that the geological training given to the engineering student must be far more fundamental and thorough than would be afforded by a brief course relating the details of certain instances of the application of geology to engineering problems. It is necessary that the student be grounded in the general principles of dynamical and structural geology especially, if he is to appreciate the significance of geological phenomena when he encounters them, and be able to reason intelligently and correctly concerning them. The instructor cannot hope that the members of his class will always have to deal with the same problems which he may present to them in the lecture room. Perhaps they may never meet just the same set of conditions which he describes as occurring in concrete cases. The important thing is to open the eyes of the men to the fact that in the past a knowledge of geology has made possible the solution of many difficult engineering problems, that the lack of such knowledge has often caused disaster and failure, that in the future this history will certainly repeat itself, and that if they are to meet such emergencies properly they must provide themselves with the necessary equipment.

Nothing appeals so strongly to the practical man as a specific case to illustrate a given proposition. The value of concrete instances in illustrating the application of geology to engineering problems can hardly be overestimated. The student may forget an abstract geological principle before he has left the lecture room; but he will remember an actual case, illustrating the application of that principle, for years. It seems to me that a most important part of the work in teaching applied geology is the securing of details regarding actual cases in which geology has been used to such advantage by practical men. Many such cases can be found by looking over the literature; but another source

of wealth is to be found in the cases which come to the knowledge of geologists and engineers, but which have never found their way into print. One cannot help wishing that these edifying experiences might be made available for the benefit of the younger and less experienced men by publication of the valuable technical details stripped of the personal features which might otherwise make the publicity distasteful to some of those concerned. Many are the valuable object lessons that would thus be presented to the younger engineers and geologists.

Shall the courses in applied geology be given as distinct courses after the student has acquired a knowledge of the principles of dynamical and structural geology, or shall the two phases of the work be presented simultaneously? In some cases it has seemed best to present the more theoretical aspects of the subject, together with the fundamental principles as established by careful investigation, as separate and systematic courses in dynamical and structural geology, embodying in a later course the application of these principles to practical problems. The alternative is to give the applied geology with the pure geology by showing the possible application as soon as each principle is fairly established. It seems to me that the latter method has the great advantage of arousing and holding the interest of the engineering student by showing him the practical value of the knowledge he is acquiring, and of fixing firmly in his mind the general principle by means of the more readily remembered illustration. For example, if the general discussion of folded strata, including the different types of monoclinal, anticlinal, and synclinal folds and their general effects upon the rocks involved, be followed by a consideration of the effects of such folds upon engineering enterprises, the student finds the subject of more vital interest to him than would be the general discussion alone. The mining engineer sees the practical value of the subject when he learns the effects of anticlines on the accumulation of oil and gas, the manner in which synclinal troughs serve to collect deposits of metallic ores, the manner in which saddle reefs and inverted saddles are formed, and the importance of such folding in developing fissures along the crests of anticlines and in the troughs of synclines. The detailed discussion of the various mining regions may come later in a course in economic geology, but some reference to the effects of folding on mining problems seems to prove helpful at this point. The fact that pitching troughs and anticlines may prove deceptive is then pointed out, the nature of their outcrops explained, and the effects on exploration and development work

discussed. If this be followed by an account of some special case, as where two engineering students working on their thesis succeeded in demonstrating the presence of a pitching fold where none was suspected before — a discovery which eventually led to the opening up of valuable ore bodies — then the student is more ready to appreciate the value of the subject of folds than he would ever be if only the abstract discussion were presented at that time, leaving the practical application till a later course.

So also in the case of the civil engineer: if he is told that the folding of brittle sandstone in a low syncline is apt to break or fissure the rock so that it becomes like an arch inverted and with the "keystone" hanging downward, he may forget it. But when the case of a Pennsylvania tunnel driven into a hill composed of sandstone in this condition, which resulted in the removal of the support from under the keystone and the consequent caving in of extensive masses of the rock, is brought to his attention, the feature of folding referred to will not soon escape his memory. He might forget a statement that shales which appear solid and massive when first exposed to the air tend to crack and crumble later on; but he will not forget that a certain tunnel driven in such shales, and not lined because the rock appeared so solid and massive when penetrated, collapsed and caused disaster when the shales dried and crumbled.

The value of the general principle itself must not be overlooked in emphasizing the concrete illustration. The principle has a value independent of any application. But to that class of men who come to seek the practical applications of geology more especially, such illustrations serve a most important end in fixing the principal points in mind, in arousing a healthy interest in the work, and in awakening the student to the possibilities of practical utility offered by an intelligent application of the principles of the science.

THE MICROSCOPIC ESTIMATE OF BACTERIA IN MILK[1]

By FRANCIS H. SLACK, M.D.

WITHIN a comparatively short time many cities have awakened to the wisdom and necessity of establishing a bacterial standard for milk. As there are, as yet, no standard methods for the bacterial and microscopic examination of milk, each laboratory has had to work out its own methods. Work along this line was begun in Boston, under the direction of Dr. H. W. Hill, in May, 1904, about nine thousand samples having been examined to date.

Plating is almost universally used for determining the bacterial content of milk. This method is open, however, to one serious and many minor objections. The serious objection is on the time required, since when the test is completed and the number of bacteria ascertained the milk in question has been marketed and consumed. Among minor objections may be mentioned the fact that the number of colonies developing depends largely upon the composition of the media and the degree and length of incubation, besides which such care is necessary in all the details of the technique as to require the services of a trained bacteriologist.

Milk contractors, or dealers, as they are sometimes called, who have to bear the brunt of the problem of providing a clean milk supply, are asking for some quicker and less technical method of determining the bacterial quality of the milk received by them from individuals — a method by which they can have so close a supervision as to keep their mixed product well within the required limits. Russell, of Wisconsin, describes a "curd test" which is so rapid as to interfere little with the almost immediate sale of the milk.

It is the object of this paper to present another method, which is both quick and accurate, and which, although it requires careful manipulation and a certain amount of experience, does not require the

[1] Read before the Society of American Bacteriologists, December, 1905.

accuracy as to detail or large amount of expensive apparatus used in plating. The writer, in carrying out routine examinations of milk sediments for pus and streptococci, noticed that the number of bacteria found in the microscopic field apparently bore a definite relation to the number of colonies developing in the plate from the same sample. It was thought that this might be of practical value if, after prolonged comparison, it turned out to be constantly true, since there would then be no necessity to plate, incubate, and count samples which the microscope alone indicated were better than the legal requirements. Winslow,[1] using $\frac{1}{20}$ c.c. of unsedimented material, had previously applied the direct microscopic enumeration of bacteria to water and sewage. It was decided to test the method thoroughly, comparing the microscopic estimate with the actual count obtained from the plate. This comparison was carried out very carefully with over 2,200 samples, each sample being subjected to the double test — *i. e.*, centrifugalizing and plating, the microscopic estimate being made before the plate was counted, usually within a few hours after the samples were received — and an error of less than 1 per cent. was made in passing as below 500,000 bacteria to the cubic centimeter milks which in the plates showed above this limit. Over a third of the total error occurred in the first 420 samples before the method was fully developed.

The apparatus and the method for making the microscopic estimate are as follows: The special apparatus for centrifugalizing the milk, modified from one used by Stewart, of Philadelphia, consists of an aluminum disk and cover, 10 inches in diameter and $\frac{3}{4}$ inch in depth, fitted to hold twenty small glass tubes arranged radially. These tubes hold about 2 c.c. each, and are closed at both ends with rubber stoppers.

The milk sample is thoroughly shaken, the tubes filled, stoppered, inserted into their proper numbered receptacles in the disk, and centrifugalized for ten minutes at a speed of from two to three thousand revolutions a minute. Thus in each tube the whole sediment from a known quantity of milk is obtained, and may be spread over a given area. A space of about 4 sq. cm. is most convenient, being the right size to allow thorough emulsion of the sediment with a drop or two of sterile water, and to permit drying into a thin, even smear. It is convenient to smear a number of samples consecutively on a long glass slide which has previously been correctly spaced with a blue pencil.

[1] Jour. Inf. Diseases, May, 1905, Sup. No. 1.

To obtain the sediment with the least disturbance, the stopper is first removed from the inner, or cream, end; then the tube is held with the cream end downwards, the cream removed with a platinum loop, and the milk poured out; lastly, still holding the cream end down, the other stopper is carefully removed with the adhering sediment and the sediment smeared evenly with a drop of sterile water over the measured space on the glass slide, the stopper being rubbed directly on the glass until the sediment has been transferred. When this is properly done the amount of diluted sediment remaining on the stopper is practically negligible. The smear is then dried with gentle heat and stained with methylene blue.

The microscopical examination of a milk sediment thus easily prepared reveals more than any other single test. It shows the character of the milk, the approximate number and the morphology of the bacteria, and the presence of pus or streptococci.

It is not claimed that all the bacteria in the milk subjected to centrifugalization are precipitated into the sediment; but it is claimed that in 99 per cent. of the samples a representative number is so precipitated, and that this number bears a fairly constant relation to the $\frac{1}{10000}$ dilution plate culture when grown in a saturated atmosphere at 37° C. for twenty-four hours, 1 per cent. agar being used with a reaction of + 1.5.

We may say, as a rough estimate, that each coccus, bacillus, diplococcus, or chain in the $\frac{1}{12}$ oil immersion field represents one colony in the $\frac{1}{10000}$ plate from the same sample. The writer wishes to emphasize the fact that this is a coincidence stumbled upon in the course of routine work rather than a carefully worked out mathematical result. It is, of course, impossible to obtain a perfectly even smear, and the sample must be sized up by examining a number of fields. Let the observer find such a representative field, then imagine that instead of looking at a microscopic field through a $\frac{1}{12}$ oil immersion lens he is looking at his $\frac{1}{10000}$ dilution plate, and that each coccus, bacillus, diplococcus, or chain within his vision represents a colony on such a plate; and if he will make the plates also, he will find how closely in the main they agree with his microscopic estimate. That is, in most cases the count of a representative field multiplied by 10,000 gives approximately the number of bacteria per cubic centimeter. By the use of this method a good idea of the condition of a single sample of milk can be obtained in less than twenty minutes. Thirty samples

can be examined in an hour. At the contractor's receiving station one man could easily examine 100 to 200 samples daily, thus keeping close watch over the dairies. There is no reason why; with such a method well established and in good working order, the mixed product should not be very low in bacteria, since the only excuse for excessive bacterial contamination of milk is ignorance, carelessness, or improper handling; and so rigid a supervision, with proper educational notices, would quickly bring the recalcitrant dairies to time or retire them in favor of their more progressive neighbors.

In city inspection only those samples need be plated which are doubtful or above the limit established. In this work the plate would corroborate the microscopic findings and strengthen the evidence for court cases. Where plates are to be made the microscopic estimate gives an indication of the proper dilution to use.

In its present state this method would probably be of no practical value in determining numbers accurately; for instance, it would be impossible to state if a milk contained twenty, thirty, forty, or fifty thousand bacteria per cubic centimeter. The writer, however, believes that this method is practical for certifying milk as below 50,000 bacteria per cubic centimeter, and that any milk which, in a sediment so prepared, shows no bacteria on microscopic examination is harmless from a bacterial standpoint, leaving out of the question, of course, typhoid or other infectious diseases. The large number of samples which could be examined and the increased efficiency of the supervision thus obtained would compensate many times over for the loss of a slightly greater accuracy in plate counts.

BOSTON BOARD OF HEALTH LABORATORY,
January 27, 1906.

A STUDY OF THE LAWS GOVERNING THE RESISTANCE OF BACILLUS COLI TO HEAT[1]

By STEPHEN DeM. GAGE and GRACE VAN EVEREN STOUGHTON[2]

In a previous communication from the Lawrence Experiment Station[3] it was shown that while a considerable majority of both *Bacillus coli* and *B. typhosus* are destroyed by a comparatively short exposure to unfavorable conditions, a few individuals in every culture proved to be much more resistant, and survived after treatment which had destroyed more than 99 per cent. of the bacteria in the given culture.

It is generally conceded that *B. coli* and *B. typhosus* do not form spores; nevertheless, the extraordinary resistance which a few organisms in every culture exhibit would lead to the conclusion either that they were in a form closely simulating true spores, or that, as is the case in all biological species, the stronger individuals were brought into prominence by the conditions imposed.

If we accept the first hypothesis, that the supposedly non-spore-bearing species may after all take on a specially resistant form akin to the true spore state, we might expect that cultures which were out of their natural habitat, and had been, presumably, attenuated by exposure to unnatural conditions, would contain a larger percentage of these resistant organisms than would a fresh laboratory culture. On the other hand, if the resistant few are of a more hardy nature, by subjecting successive generations to conditions such that only the

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[1] Read at the seventh annual meeting of the Society of American Bacteriologists, December 29, 1905.

[2] The studies here reported were made late in 1904, while Mrs. Stoughton was a volunteer research assistant at the Lawrence Experiment Station. While the studies were still incomplete, Mrs. Stoughton returned to New York, and to our great sorrow died shortly afterward. The writer has endeavored to present fairly the theories upon which the experiments were founded and the bearing which the accumulated data have on those theories, without attempting to obtain additional evidence. Mrs. Stoughton should receive full credit for the active part which she took in the investigation, but she should not be held responsible for any conclusions which have been drawn therefrom.

[3] Thirty-fourth Annual Report Massachusetts State Board of Health, 1903, p. 268.

hardy individuals would survive, and causing these to become the progenitors of a new race, according to the theory of evolution by the survival of the fittest, we would expect that our successive generations would gradually become stronger, and that in the end we should have a race in which a larger proportion of the individuals would be able to successfully resist the given conditions than was the case in the original culture.

Some experiments made at the Lawrence Experiment Station appear to throw some light on these points. In these experiments the phenomena resulting from the exposure of cultures of *B. coli* to different temperatures were studied. In one experiment (No. 195) successive generations of a given culture were subjected to thermal death-point tests, those bacteria which most successfully resisted the application of heat becoming the progenitors of a new culture to which the thermal death-point tests were again applied, the attempt being made to produce in this manner a race of bacteria in which the characteristics of the more hardy individuals of the original culture should become predominant. In the second experiment (No. 197) sterile water was seeded with bacteria from the original culture, and was allowed to stand in the laboratory for stated times before the thermal death-point tests were applied, in order that the bacteria might have a chance to take on the more resistant character which spore-bearing types usually assume when removed from their natural habitat for any length of time.

Procedure. — The culture selected for experimental purposes was one which had been isolated from normal stools about three months previously, and which an exhaustive study had proved to be a typical *B. coli.* Before use the culture was plated out to insure purity, and was then revivified by carrying it through three successive cultivations in broth, each culture being incubated twenty-four hours at body temperature. The resulting broth culture was then diluted with sterile tap water, and 3 c.c. of this water culture were placed in each of a number of sterile test tubes, all of which were carefully selected to insure uniformity of bore and thickness of glass. Each of these tubes was then immersed for exactly five minutes in a water bath kept accurately at the desired temperature, after which the contents were immediately plated on agar, and an equal volume of broth was mixed with the culture remaining in the tubes. Temperature readings, with the thermometer inside the tubes, showed that the cultures reached the

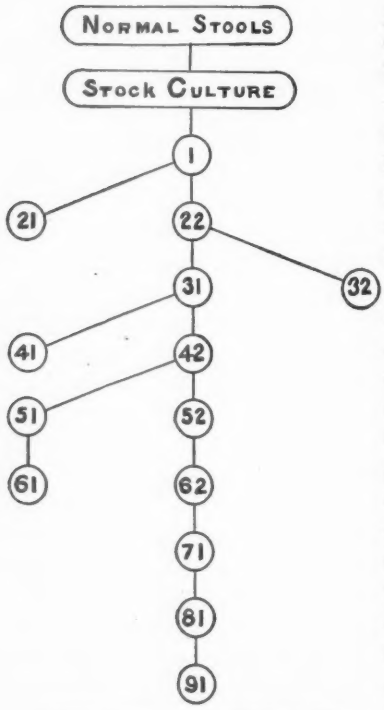
temperature of the bath in less than thirty seconds, the five-minute period, however, being reckoned from the time the tubes were placed in the bath. The temperatures in every case ranged from 40° C. to 100° C. by intervals of 5°. The agar plates and the broth cultures were incubated eighteen hours at body temperature, after which the plates were counted and the presence or absence of growth noted in the broth cultures. The procedure in the thermal death-point tests was the same throughout the investigation. A careful examination of a large number of cultures isolated during the various stages of the two experiments proved that no contamination had occurred during the many transfers made, and no modification in the characteristics of the culture could be detected by the usual methods of species determination even after it had passed through nine generations which had been heated to near the thermal death-point.

Expression of Results. — In comparing the results obtained in experiments of this character, especially when dealing with cultures in which the initial numbers of bacteria vary through wide limits, the relations between the changes produced by identical treatment are often obscured by differences in the numbers of bacteria in the various cultures. It has been found in previous investigations that the true relation between results of different portions of experiments of this character is best shown when the results are expressed on a percentage basis, that is, when we express each result, not as the actual number of bacteria found, but as the ratio of that number to the number of bacteria in the control culture. The results shown in the tables further on have been computed in this manner, the initial numbers of bacteria having been reduced to 100,000 and the various bacterial determinations having been reduced in the same ratio. Another advantage in this method of expression is that we are able to average the results of different experiments with absolute mathematical fairness. The sign plus (+) in the tables indicates that no colonies appeared on the plates, but that a growth in the broth cultures showed that the cultures were not entirely sterile.

A further difficulty becomes apparent when we attempt to plot the curves of bacteriological experiments. If we plot these curves on a scale which will show the variations in both the larger numbers and in the smaller numbers, our curves become too large for practical reproduction, while if we reduce the scale we are able to show only the general curves without the minor fluctuations which are often so

significant. This difficulty is best overcome by plotting on a logarithmic scale, the minor differences being well distinguished by this method; and while the height of the scale is materially reduced, the consequent foreshortening of the curves does not affect the impression which they are intended to convey. The writer has used the logarithmic scale for plotting bacterial curves for many years with entire success, and the curves in Diagrams Nos. II and III have been drawn in this manner.

DIAGRAM I



GENEALOGICAL SEQUENCE OF THE CULTURES IN EXPERIMENT 195

Experiment 195. — In this experiment it was attempted to establish a race of *B. coli* in which a majority of the bacteria should simulate the characteristics of the more hardy individuals of the original culture by applying the theory of the survival of the fittest. The counts on the plates made after the thermal death-point determinations with the original culture (culture No. 1) showed that about 30 per cent. of the organisms had been destroyed at 50°, and about 96 per cent. at 55°. Only a few individual organisms survived at temperatures ranging from 60° to 90°, and at 95° and above the cultures were sterile. On the second day dilutions were made of the broth cultures from the samples which had been heated to 90° and 60° on the previous day, and portions of these water cultures were treated as before, these cultures being called Nos. 21 and 22, respectively (Diagram I). With culture No. 21 over 20 per cent. of the bacteria were destroyed by five minutes' exposure to 45° C. and over 70 per cent. by exposure to 50° C. At 55° C. practically all of the bacteria had been killed, as was the case at 65°, all of the higher temperatures having sterilized the cultures

exposed to them. With culture No. 22 a somewhat similar decrease was noted at 45° and 50°, the percentage reduction being 14 per cent. and 96 per cent., respectively, at those temperatures. At 55° all but a few individuals had been destroyed, as was the case up to 75°, and at 80°, although no colonies appeared on the plates, a growth occurred in the broth culture. Above 80° the cultures were sterile.

Two cultures from No. 22 which had survived heating to 80° and 60° on the second day were selected for the tests on the third day, these cultures being called Nos. 31 and 32, respectively. The plate counts showed that 100 per cent. and 44 per cent. of the bacteria from culture No. 31 had survived 45° and 50°, respectively, and a few colonies appeared on the plates from cultures which had been heated to temperatures ranging from 55° to 80°. The 85° culture failed to develop on the plates, but was able to grow in broth. Above 85° all of the cultures were sterile. Culture No. 32 proved to be somewhat less resistant than No. 31, 71 per cent. of the organisms being destroyed at 45° and 87 per cent. at 50°. At 55° to 70° and at 80° a few organisms survived, while at 75° and at all temperatures above 80° the cultures were sterile.

On the fourth day the 80° and 55° cultures from the previous day's treatment of culture No. 31 were chosen, being called Nos. 41 and 42, respectively. These two cultures reacted more like the original culture than did any of the other cultures tested, in the fact that considerable numbers of each were able to grow after heating to 55°. This may possibly have been due to some modification of the conditions of the experiment, although every attempt was made to have these conditions uniform. With culture No. 41, 23 per cent., 11 per cent., and about 1 per cent. of the organisms were able to resist temperatures of 45°, 50°, and 55°, respectively. Above 55° the results were very erratic. At 60° and at 75° the cultures were sterilized completely. At 70° and at 75° no colonies appeared on the plates, although a growth occurred in the broth, while at 80° nearly three hundred colonies appeared on the plate. Above 85° all of the cultures were sterile. With culture No. 42 much the same erraticism was noted. Sixty-three per cent., 46 per cent., and over 2 per cent. of the organisms were able to develop after exposure to temperatures of 45°, 50°, and 55°, respectively, and a few colonies appeared on the plates from the 60° and 65° cultures. The temperature of 70° effectively sterilized the culture; but temperatures of 75° and 80° failed to com-

pletely sterilize, as shown by a growth in broth, although no colonies developed on the plates made from these cultures. Above 75° all the cultures were sterilized.

Cultures of No. 42 which had shown growth after heating to 80° and 60° C. on the fourth day were chosen for the tests on the fifth day, these cultures being numbered 51 and 52, respectively. With culture No. 51, 34 per cent. survived a temperature of 45° and over 5 per cent. survived a temperature of 50°, while a few colonies appeared on plates made from cultures which had been heated to 55°, 60°, and 65°, respectively. No colonies appeared on the plates made from the culture which had been heated to 70°, but a growth occurred in the broth culture, showing that all of the organisms had not been killed. Temperatures above 70° effectually destroyed all of the bacteria in this culture. With culture No. 52, 72 per cent. of the organisms were alive after exposure to 45° and 20 per cent. after exposure to 50°, while after exposure to 55° and 60° a few organisms were able to grow on the plates. The plates made from the culture which had been heated to 65° were sterile; but there was a growth in the broth cultures, showing that sterilization was not complete. Plates and broth cultures made from samples which were exposed to temperatures above 65° showed no growth.

On the sixth day a change was made in the method of selecting cultures from the previous day's tests, the culture which had been heated to 55° being taken from each of the stock cultures Nos. 51 and 52, the culture from stock No. 51 being numbered 61, and that from the stock No. 52 being numbered 62. These two cultures reacted much alike when subjected to thermal death-point tests. At 45° 27 per cent. of the organisms of culture No. 61 were destroyed and 37 per cent. of the organisms in culture No. 62, while at 50° the percentage destruction of bacteria in the two cultures was 69 per cent. and 77 per cent., respectively. After heating to 55°, only a small number of bacteria remained alive in each culture, and at 60° and above sterilization was complete.

Only one culture was tested on the seventh day, this being one from stock No. 62 which had been heated to 55° on the preceding day. No destruction of bacteria occurred when this culture was heated to 45°, the number of colonies developing on the plates being more than twice as great as in the control culture. At 50° more than 95 per cent. of the organisms were killed, while at temperatures ranging from 55° to

TABLE I—Showing the Relative Behavior of Successive Generations of a Culture of B. Coli when Subjected to Thermal Death-Point Tests

	Temperature.	First Generation.	Second Generation.		Third Generation.		Fourth Generation.		Fifth Generation.		Sixth Generation.		Seventh Generation.	Eighth Generation.	Ninth Generation.
		No. 1	No. 21	No. 22	No. 31	No. 32	No. 41	No. 42	No. 51	No. 52	No. 61	No. 62	No. 71	No. 81	No. 91
Initial number of bacteria	. .	889,000	470,000	440,000	220,000	260,000	230,000	410,000	42,000	79,000	15,500	12,000	209,000	1,950,000	2,550,000
Relative numbers of bacteria	Start	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
	45° C.	136,000	79,000	86,000	100,000	29,000	23,000	63,000	34,000	72,000	73,000	63,000	258,000	64,000	243,000
	50° C.	70,000	29,000	3,600	44,000	13,000	11,000	46,000	5,200	20,000	31,000	23,000	4,500	9,700	49,000
	55° C.	4,400	70	6	50	5	900	2,300	7	4	570	20	20	12	200
	60° C.	1	0	8	10	300	0	1	2	90	0	0	160	2	0
	65° C.	250	1	400	1	1	+	1	300	+	0	0	20	0	0
	70° C.	30	0	1	2	20	+	0	+	0	0	0	10	0	22
	75° C.	50	0	14	3	0	0	+	0	0	0	0	0	0	0
	80° C.	15	0	+	3	1	90	+	0	0	0	0	0	0	18
	85° C.	3	0	0	+	0	0	0	0	0	0	0	0	0	0
	90° C.	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	95° C.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	100° C.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

70° only small numbers remained alive, and above 70° the cultures were sterile.

On the eighth day a culture which had survived heating to 70° on the preceding day was selected for the thermal death-point determinations. After heating to 45° about 64 per cent. of the bacteria in this culture were yet alive, and after heating to 50° nearly 10 per cent. still survived. Temperatures of 55° and 60°, while sufficient to destroy a considerable majority of the organisms, did not entirely kill the culture, as shown by small numbers of colonies which were able to develop on the plates. Temperatures of 65° and above proved effective in sterilizing this culture.

On the ninth day the tests were made on a culture which had been heated to 55° on the eighth day. The results showed that the culture was unaffected by a temperature of 45°, but that a reduction of 51 per cent. occurred when heated to 50°. Considerable numbers of the organisms were unaffected by temperatures of 55°, 70°, and 80°, while the cultures subjected to temperatures of 60°, 65°, 75°, and 85° and above were sterilized. Circumstances over which we had no control prevented tests being made on the tenth day, and the sequence being broken the experiment was discontinued. The genealogical sequence of the various cultures is shown in Diagram I, and the results of the analyses are shown in Table I.

Experiment 197. — In this experiment it was attempted to produce a condition in which a non-spore-bearing type of organisms should be induced to simulate formation of spores by assuming a more resistant form than it had shown in laboratory cultures. Four bottles of sterile water were seeded with bacteria from the surface of an agar streak of the same stock culture as that used in the former experiment, these water cultures being allowed to stand in the laboratory for twenty-four hours, forty-eight hours, three days, and six days, respectively, after which portions of each culture were transferred to tubes and the thermal death-points determined, as in the preceding experiment. The thermal death-point tests on the original culture (Experiment 195, No. 1) showed that a majority of the organisms in the culture were destroyed by five minutes' exposure to a temperature of 55° C., but that a few organisms were able to resist temperatures as high as 90° C. With the twenty-four-hour water culture about 4 per cent. of the bacteria were destroyed at 45°, 30 per cent. were destroyed at 50°, 86 per cent. were destroyed at 55°, and nearly 99 per cent. were killed

at 60°. A few organisms, however, survived temperatures ranging from 60° to 90°, as shown by colonies on the plates or by a growth in broth. At 95° and 100° the cultures were sterilized. With the forty-eight-hour water culture the reactions were quite similar to those of the twenty-four-hour culture. At 45° no reduction occurred in the number of organisms, at 50° the reduction was 34 per cent., and at 55° 88 per cent. of the bacteria were killed. At temperatures of 60°, 65°, and 75° a considerable number of organisms still remained alive, although the total reduction had been over 99 per cent., and at the other temperatures up to 90° small numbers developed on the plates or growths occurred in broth. Above 90° sterilization was complete. The three-day water culture proved to be somewhat different from the two cultures just discussed. At 45° no reduction occurred, the numbers of bacteria being higher after the exposure to that temperature than in the control. At 50° a reduction of about 25 per cent. occurred, and at 55° a reduction of about 80 per cent. was noted. Above 55°, however, with the single exception of the culture which had been heated to 75°, no colonies were found on the plates, although growths in the broth cultures showed that complete sterilization was not accomplished by any temperature below 90°. The six-day culture showed the same general character as did the three-day culture. At 45°, 50°, and 55°, respectively, the reductions in the numbers of bacteria were 31 per cent., 55 per cent., and 86 per cent., while at temperatures ranging from 60° to 85° growths occurred only in the broth, no colonies developing on the plates. Temperatures of 90° and above effectively sterilized this culture. The results obtained in this experiment are shown in Table II.

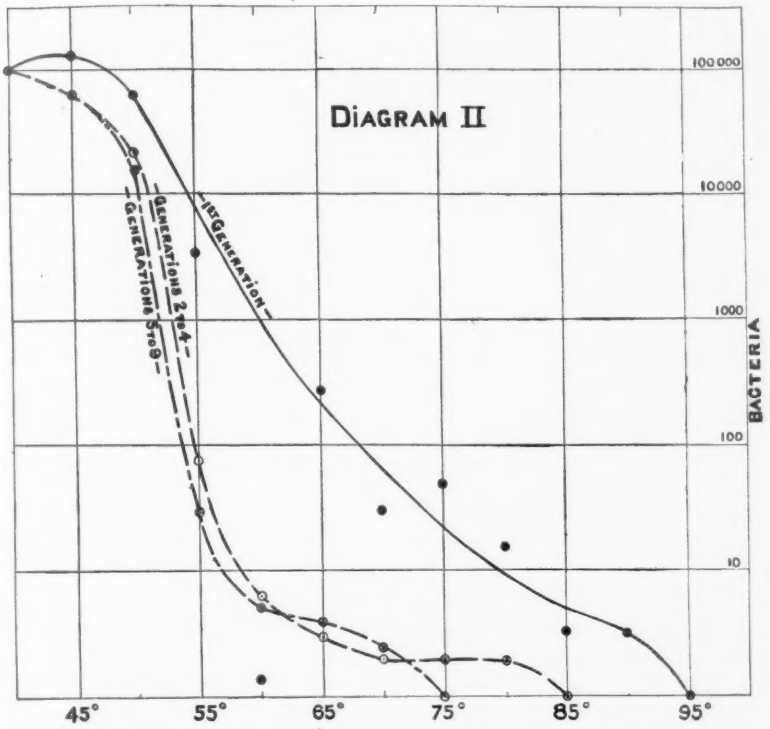
TABLE II — SHOWING THE RELATIVE BEHAVIOR OF WATER CULTURES OF B. COLI WHICH HAVE BEEN STANDING DIFFERENT LENGTHS OF TIME WHEN SUBJECTED TO THERMAL DEATH-POINT TESTS

	Temperature.	Twenty-four-hour water culture.	Forty-eight-hour water culture.	Three-day water culture.	Six-day water culture.
Initial number of bacteria	. .	13,000,000	25,000,000	14,760,000	17,000,000
Relative numbers of bacteria	Start	100,000	100,000	100,000	100,000
	45° C.	96,000	103,000	151,000	69,000
	50° C.	70,000	66,000	74,500	45,500
	55° C.	14,000	12,800	20,600	13,700
	60° C.	1,300	105	+	+
	65° C.	1	195	+	+
	70° C.	90	5	+	+
	75° C.	+	280	80	+
	80° C.	1	+	+	+
	85° C.	+	6	+	+
	90° C.	+	+	0	0
	95° C.	0	0	0	0
	100° C.	0	0	0	0

Conclusions. — In a consideration of experiments such as these, where considerable erraticism has occurred in the individual results, and where the data acquired are incomplete and more or less inconclusive, any conclusions which may be drawn must always be open to criticism. A study of the data accumulated, however, brings to light certain very interesting features of the general trend of the experimental results, and furthermore certain facts have been ascertained which have an important bearing on the use of thermal death-point tests in the identification of bacterial species.

Neither of the previously stated hypotheses as to why a few individuals in all cultures are able to resist conditions which are fatal to the large majority of the bacteria in the culture appears to be sustained by the experimental data. Experiment 195, in which we attempted to produce by the survival of the fittest a race of especially resistant organisms, demonstrated a diametrically opposite result, while Experiment 197, in which we tried to make a race of non-sporulating bacteria simulate spore formation by placing them under conditions unfavorable to their development, also failed in its purpose. It is

quite possible, however, that more conclusive results might have been obtained if the experiments had been continued over longer periods of time. The general tendency of both experiments has been toward the establishment of a race in which the more resistant individuals would be entirely eliminated. This is not very clearly shown in the tables, and if the bacteria-temperature curves for each of the individual



LOGARITHMIC CURVES OF TEMPERATURE RESISTANCE, EXPERIMENT 195

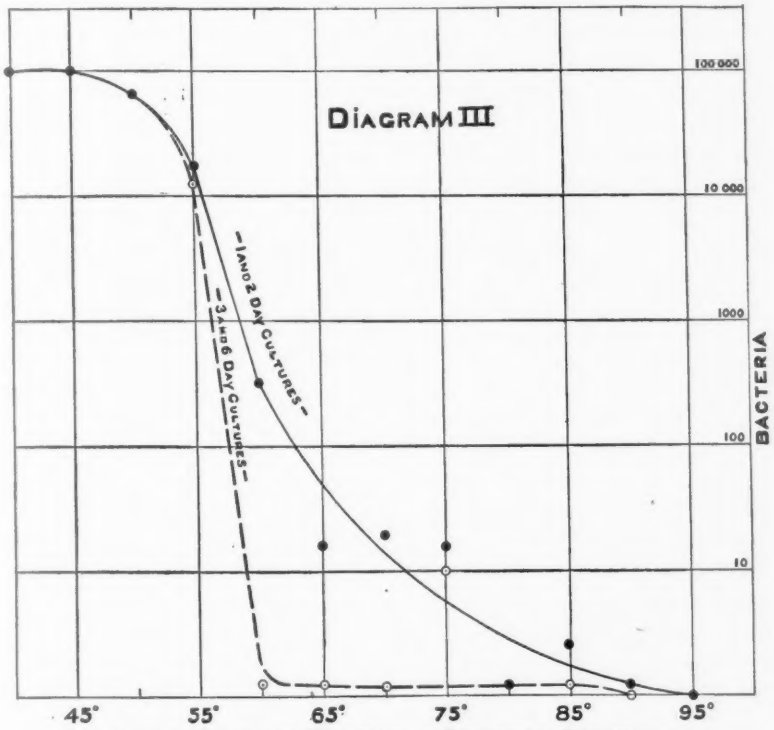
determinations be plotted, this tendency is partially obscured by the erratic behavior of some of the cultures. If, however, the results obtained in the first portion of each experiment are averaged and the curves plotted, omitting values which are obviously abnormal, and the results obtained during the latter portions of the experiments be similarly treated, this tendency toward a culture composed of individuals of more uniform resistance is demonstrated. In Diagram II

three curves of temperature resistance are plotted using the results obtained in Experiment 195, one of these curves being that for the original culture, *i. e.*, the first generation, the second being the average curve for the second, third, and fourth generations, and the third curve being the average for the last five generations. The points used in drawing the curves for the first generation are quite irregularly placed, and it has been impossible to draw a true curve through them. The line as drawn probably represents the true temperature resistance of the original culture. This curve breaks sharply at 50°, and descends in a long, gradual sweep to absolute zero at 95°. The average curve for the second, third, and fourth generations breaks at 50°, the drop being much more rapid than in the first curve and the zero point being reached at 85°. The curve for the last five generations is similar to this second curve, but differs from it in that the decline is somewhat more marked after the break at 50° and that the zero point is reached at 75°. The great uniformity of the cultures included in these last two curves is shown by the position of the various points with reference to the curves. The tendency of the experiment, as indicated by these curves, has been toward the elimination of the majority of the bacteria surviving temperatures above 55° and toward the ultimate production of a culture whose majority thermal death-point is about 50° and whose absolute thermal death-point is apparently between 50° and 60°. The difficulty in eliminating the few resisting individuals is shown by the horizontal approach of the last two curves before they dip to the zero point.

Plotting similar curves for Experiment 197, we find that a similar conclusion is indicated. In Diagram III two curves are shown, one being obtained by averaging the results from the one and two-day cultures, and the other by averaging the results from the three and six-day cultures. The first curve breaks sharply at 55° and descends in a long, gradual sweep to absolute zero at 95°, while the points by which the curve was drawn are somewhat irregularly placed in the higher temperatures, as was the case for the original culture (Diagram I, first generation). The second curve breaks sharply at 55° and descends almost to zero at 60°, then follows a horizontal line to 85°, dropping to absolute zero at 90°. In this second curve all the points fall in line except the one at 75°. The tendency to eliminate all but a few specially resistant bacteria and toward the ultimate production of a race of bacteria whose majority and absolute thermal

death-point shall be practically the same is again illustrated in these curves.

On four of the days on which thermal death-point tests were made in Experiment 195, duplicate tests were made on two cultures from the same stock of the preceding day, one of the cultures tested having originated from the organisms which had survived a temperature just



LOGARITHMIC CURVES OF TEMPERATURE RESISTANCE, EXPERIMENT 197

above the normal thermal death-point, while the other culture tested had originated from the organisms which had survived a temperature just below the absolute thermal death-point. A careful comparison of the thermal death-point tests with these two classes of cultures fails to reveal any difference in their behavior, either when studied individually or when the two series of results are averaged.

The most important facts noted in the investigation are the resistance

of some of the organisms to temperatures considerably higher than have been previously recorded for this species under similar conditions, and the practical uniformity in the temperature at which the larger number of the bacteria have been destroyed as contrasted with the variation in the actual thermal death-point. In the procedure generally recommended for the determination of the presence or absence of spores, broth cultures of the species under examination are immersed in a water bath at a temperature of 80° C. for five minutes, and if any organisms are able to develop in the broth after such treatment the species is presumed to be included among the spore-bearing types. During the eighteen different thermal death-point tests made a few organisms resisted temperatures of 80° C. or over for five-minute periods in over 55 per cent. of the determinations. Relying on the thermal death-point tests alone, we must include the culture used for these experiments among the spore-forming bacteria, although careful morphological examination has repeatedly failed to show any evidence of true spores. The interpretation of what constitutes spore formation would appear to require careful study before we make use of that factor in a natural classification of bacteria. In contrast to the wide variation in the absolute thermal death-point of the various cultures is the practical uniformity in the temperature at which the majority of the bacteria in all cultures were destroyed. The temperature at which final sterilization occurred varied from 60° to 95° in the eighteen different tests, while the death-point for the majority of the bacteria lay between 50° and 55° in the fourteen tests made in Experiment 195, and between 55° and 60° in the four tests made in Experiment 197 — a total range of only 10° as compared with a range of about 35° in the absolute death-point. The fairly constant results obtained in the determinations of this temperature, *i.e.*, the normal thermal death-point, would lead to the belief that its application in the identification of bacterial species would be of more value than is the determination of the absolute thermal death-point.

BOOK REVIEWS

Methods of Organic Analysis[1]

That a substantial and somewhat diversified course of laboratory practice in the methods of organic analysis should form part of the training of every professional chemist is now a generally recognized fact. The successful conduct of a large and increasing proportion of our chemical industries, as well as the protection of the consumer, demands all the aid which a skillful application of these methods is able to bring.

Professor Sherman's book, written from the viewpoint of a very competent food analyst, contains the well-ordered material for such a course of instruction. In the words of its author, "Its purpose is to give a connected introductory training in organic analysis, especially as applied to plant and animal substances and their manufactured products."

The opening chapters contain full working directions for the leading methods of ultimate analysis, except for those employing the combustion furnace. Chapters III and IV, on aldehydes and alcohols, deal chiefly with ethyl, methyl, and amyl alcohols, glycerine, and formic aldehyde. Chapters V, VI, and VII are devoted to the carbohydrates, treating, respectively: general qualitative and quantitative methods, especially those based on the use of the polariscope and copper reduction; applications of sugar analysis; the determination of starch, and the separation of carbohydrates in cereal products. The leading topics in Chapter VIII, on acids, are acetic acid, acetates, and vinegar. The standard methods for the examination of the oils, fats, waxes, butter, soaps, and lubricants are well described in Chapters IX to XII. Chapters XIII and XIV are devoted to proteids and the analysis of cereal products, and the determinations of milk analysis.

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[1] Methods of Organic Analysis. By Henry C. Sherman. New York: Macmillan. xii + 245 pp., 8vo. Cloth, $1.75.

The descriptions of processes are everywhere accompanied by concise expositions of fundamental facts, principles, and applications. The addition of cuts would in some instances be an advantage to the beginner, but the manner of presentation is so clear and orderly that their absence is not felt as a serious defect.

Although written primarily for the use of college students, the critical comment on processes and on the interpretation of results is so sound and discriminating, and the bibliographical references to the important recent literature of each topic are so complete and well arranged, that the book will repay examination by any analyst. It is an undoubtedly valuable contribution to our analytical literature.

S. P. MULLIKEN.

EXPERIMENTAL ELECTRO–CHEMISTRY[1]

THIS book is intended for use in the lecture room and the laboratory. After a brief historical introduction the theory of electrolytic dissociation is explained from an experimental standpoint. The chapter following is devoted largely to descriptions of some experiments of the author's on "electrolytic induction," which do not seem of sufficient interest or importance to the student to warrant being given at such length. Faraday's Law and voltameters are next discussed. In the chapter on energy required in electrolysis, Thomson's Rule is given and explained by some examples; the name, however, is suppressed, and its limitations are not mentioned. In the same chapter a little is said about electro-analysis. The following five chapters deal with commercially important electro-chemical processes for manufacturing chemical compounds (omitting the refining of metals), with directions for carrying them out as laboratory experiments. The author gives long lists of various points to be noted in these experiments, but neglects to point out the importance of computing efficiencies from the data obtained. In a work of this kind it also seems an omission to give the student no idea of the cost of electrical energy. The chapter on the electric furnace and furnace products is too brief to give any idea of the importance of this branch of the subject, and the preparation of organic compounds is

[1] Experimental Electro-Chemistry. By N. Monroe Hopkins. New York: Van Nostrand, 1905. 14 + 284 pp., 131 il.

also very briefly treated. In the chapter on the primary cell Ostwald's experiment illustrating "chemical action at a distance" is clearly and correctly explained; but the same cannot be said of the explanation of the reason why pure zinc does not dissolve readily in acids, for the impression given here is that the phenomenon of "overpressure" is related to the electrolytic solution pressure of the metal in question. The chapter on secondary batteries is confined to lead accumulators. In the chapter on electricity from carbon, the Edison and Jacques cells are described. Contrary to a statement in this connection, in the case of the last mentioned cell, at least, the current is not of thermo-electric origin. In the final chapter some electro-chemical apparatus, such as conductivity cells, are described.

There is a chronologically arranged bibliography at the end of the book. The impression left on the reader after perusing this work is not improved by the misspelling of certain well-known names, such as Becquerel, Seebeck, and Borchers.

Although this work has certain defects which are more or less necessarily inherent in any book which attempts to treat so large a subject in a limited space, the style is such as to hold the attention, and the interest in the subject is increased by the historical treatment adopted.

M. DeK. Thompson, Jr.

American Institute of Electrical Engineers[1]

We are in receipt of two volumes, bound edition, of the *Transactions of the American Institute of Electrical Engineers*. Volume XXII covers the period from July to December, 1903, and is devoted largely to the proceedings of the twentieth general meeting at Niagara Falls, June 29 to July 3, 1903. The principal subjects discussed are electric railways, power transmission, engineering education, electro-hydraulics, electric traction, electro-chemistry, and central stations. Volume XXIII covers the year from January to December, 1904, and includes the proceedings of the annual meeting at New York in May, 1904, and the annual convention in St. Louis, September 14, 1904. In this volume

[1] American Institute of Electrical Engineers, Transactions, XXII and XXIII. New York, 1904–05.

will be found papers and discussions on alternating current railway motors, high pressure lines, high pressure transmission, alternating current generators, high tension transmission, transmission of intelligence, heavy electric traction, and the problem of the distance to which power can be transmitted economically.

The particular method of publication employed by the American Institute of Electrical Engineers certainly has advantages, but it also has its disadvantages. While it adds greatly to the ease of reading in bound volumes to have the papers and discussions on the same subject printed continuously, although written by various authors and delivered at different places and different meetings; on the other hand there has been danger of confusion in matters of reference. For example, a person who had read in the monthly edition Mershon's paper on the "Maximum Distance to Which Power Can Be Economically Transmitted," and wished to make a bibliographical reference to this, would put it as appearing in the *Transactions of the American Institute of Electrical Engineers*, Volume XXI, pages 871–892; but if again wishing to refer to the article, and looking in the bound volumes, he would find it, not in Volume XXI at all, but in Volume XXIII, pages 759–781. The confusion which is caused by this arrangement has been partly obviated, however, by a new departure on the part of the Institute. The monthly transactions are now published, beginning with the January number for 1905, under the title of "Proceedings," while the title "Transactions" is retained for the annual bound volumes. The "Proceedings" begin with Volume XXIV, No. 1, and the last number of the monthly issue of the "Transactions" is Volume XXI, No. 10; so there will be no Volumes XXII and XXIII of the monthly publication.

Asbestos and the Asbestos Industry[1]

An idea of the rapid growth of the asbestos industry in Quebec may be gained from the fourfold increase in production during the last decade. It seems fitting, therefore, that the story of progress and existing conditions should be told at the present time.

[1] Franz Cirkel: Asbestos, Its Occurrence, Exploitation, and Uses. Mines Branch. Dept. of the Interior, Ottawa, 1905. 169 pp., 19 pl., 38 il., map.

The author makes eight main divisions of the subject:—

History, Qualities of Asbestos, Geological Distribution and Characteristics of the Deposits.
Mining of Asbestos.
Dressing of Asbestos for the Market.
Costs of Extraction, Market and Price Statistics, and Status of the Industry.
Asbestos Mines and Prospects.
Asbestos in Foreign Countries.
Commercial Application of Asbestos.
Abstract of Mining Laws of Quebec, and Bibliography.

Practically all of the asbestos of Quebec is chrysotile and occurs in serpentine rocks within a comparatively small area. Owing to the nature of the deposits, the mining is almost entirely surface work in open pits, using quarrying methods. In the dressing, the larger pieces of asbestos are freed from waste rock by hand picking and cobbing, while the balance is given a mechanical treatment. The preliminary step is to crush the material by ordinary rock breakers, followed by rolls and pulverizers. This leaves the rock granular and the asbestos in fiberized form, both intimately mixed. The final step is to separate the two by the use of screens and suction fans. The evolution of the scheme of dressing is comparatively recent; it has contributed largely to the progress of the industry. Thus, material which was thrown upon the dump a few years ago is now being worked over in the mills at a profit. The individual mines of Quebec are described in detail and the chief asbestos deposits of the world are well covered. An important factor in the development of the industry is the variety of commercial applications of asbestos, which are constantly on the increase. The author describes these fully.

To one who is interested in asbestos this report is to be recommended as containing very complete information thoroughly up to date.

C. E. L.

Mica and the Mica Industry[1]

The aim of the author is to "furnish an exhaustive compilation of data and general information in the form of a concise report."

He deals first with the physical and chemical properties and

[1] Franz Cirkel: Mica, Its Occurrence, Exploitation, and Uses. Mines Branch, Dept. of the Interior, Ottawa, 1905. 148 pp., 38 il., map.

geographical distribution of the micas in general, and then considers the occurrence of muscovite and phlogopite, with special reference to the Canadian deposits. The mining operation and preparation of mica are described, and the mines of Quebec and Ontario are taken up in detail. Information is given regarding the present status of the Canadian mica industry and the commercial applications of the product. One chapter is devoted to mica in foreign countries. An appendix contains the mining laws of Ontario and Quebec.

The aim of the author appears to have been reached. The book is, in truth, a concise report. The commercial side of the industry has been particularly well covered.

C. E. L.